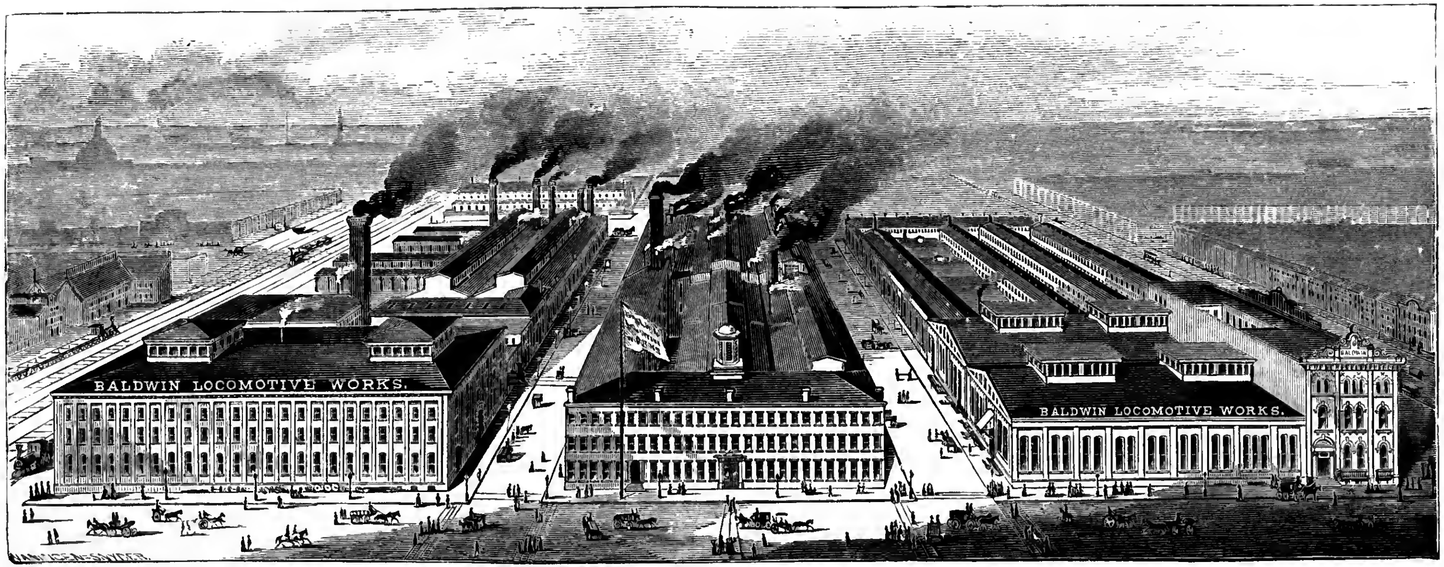
Baldwin Locomotive Works.

ILLUSTRATED CATALOGUE.



BALDWIN LOCOMOTIVE WORKS.

(Bird's-eye View.)

BALDWIN LOCOMOTIVE WORKS.

ILLUSTRATED CATALOGUE

OF

LOCOMOTIVES.

BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA.

GEORGE BURNHAM,
CHARLES T. PARRY,
EDWARD H. WILLIAMS,
WILLIAM P. HENSZEY,
EDWARD LONGSTRETH,
JOHN H. CONVERSE.

SECOND EDITION.

PHILADELPHIA:
J. B. LIPPINCOTT & CO.
1881.

INDEX.

SKETCH

OF THE

BALDWIN LOCOMOTIVE WORKS.

THE BALDWIN LOCOMOTIVE WORKS dates its origin from the inception of steam railroads in America. Called into existence by the early requirements of the railroad interests of the country, it has grown with their growth and kept pace with their progress. It has reflected in its career the successive stages of American railroad practice, and has itself contributed largely to the development of the locomotive as it exists to-day. A history of the Baldwin Locomotive Works, therefore, is, in a great measure, a record of the progress of locomotive engineering in this country, and as such cannot fail to be of interest to all who are concerned in this important element of our material progress.

MATTHIAS W. BALDWIN, the founder of the establishment, learned the trade of a jeweler, and entered the service of Fletcher & Gardiner, Jewelers and Silversmiths, Philadelphia, in 1817. Two years later he opened a small shop, in the same line of business, on his own account. The demand for articles of this character falling off, however, he formed a partnership, in 1825, with David Mason, a machinist, in the manufacture of bookbinders' tools and cylinders for calico-printing. Their shop was in a small alley which runs north from Walnut Street, above Fourth. They afterwards removed to Minor Street, below Sixth. The business was so successful that steam-power became necessary in carrying on their manufactures, and an engine was bought for the purpose. This proving unsatisfactory, Mr. Baldwin decided to design and construct one which should be specially adapted to the requirements of his shop. One of these requirements was that it should occupy the least possible space, and this was met by the construction of an upright engine on a novel and ingenious plan. On a bed-plate about five feet square an upright cylinder was placed; the piston-rod connected to a cross-bar having two legs, turned downward, and sliding in grooves on the sides of the cylinder, which thus formed the guides. To the sides of these legs, at their lower ends, was connected by pivots an inverted U-shaped frame, prolonged at the arch into a single rod, which took hold of the crank of a fly-wheel carried by upright standards on the bed-plate. It will be seen that the length of the ordinary separate guide-bars was thus saved, and the whole engine was brought within the smallest possible compass. The design of the machine was

not only unique, but its workmanship was so excellent, and its efficiency so great, as readily to procure for Mr. Baldwin orders for additional stationary engines. His attention was thus turned to steam engineering, and the way was prepared for his grappling with the problem of the locomotive when the time should arrive.

This original stationary engine, constructed prior to 1830, is still in good order and carefully preserved at the works. It has successively supplied the power in six different departments as they have been opened, from time to time, in the growth of the business.

The manufacture of stationary steam-engines thus took a prominent place in the establishment, and Mr. Mason shortly afterward withdrew from the partnership.

In 1829–30 the use of steam as a motive power on railroads had begun to engage the attention of American engineers. A few locomotives had been imported from England, and one (which, however, was not successful) had been constructed at the West Point Foundry, in New York City. To gratify the public interest in the new motor, Mr. Franklin Peale, then proprietor of the Philadelphia Museum, applied to Mr. Baldwin to construct a miniature locomotive for exhibition in his establishment. With the aid only of the imperfect published descriptions and sketches of the locomotives which had taken part in the Rainhill competition in England, Mr. Baldwin undertook the work, and on the 25th of April, 1831, the miniature locomotive was put in motion on a circular track made of pine boards covered with hoop iron, in the rooms of the Museum. Two small cars, containing seats for four passengers, were attached to it, and the novel spectacle attracted crowds of admiring spectators. Both anthracite and pine-knot coal were used as fuel, and the exhaust steam was discharged into the chimney, thus utilizing it to increase the draught.

The success of the model was such that, in the same year, Mr. Baldwin received an order for a locomotive from the Philadelphia, Germantown and Norristown Railroad Company, whose short line of six miles to Germantown was operated by horse-power. The Camden and Amboy Railroad Company had shortly before imported a locomotive from England, which was stored in a shed at Bordentown. It had not yet been put together; but Mr. Baldwin, in company with his friend, Mr. Peale, visited the spot, inspected the detached parts, and made a few memoranda of some of its principal dimensions. Guided by these figures and his experience with the Peale model, Mr. Baldwin commenced the task. The difficulties to be overcome in filling the order can hardly be appreciated at this day. There were few mechanics competent to do any part of the work on a locomotive. Suitable tools were with difficulty obtainable. Cylinders were bored by a chisel fixed in a block of wood and turned by hand. Blacksmiths able to weld a bar of iron exceeding one and one-quarter inches in thickness were few, or not to be had. It was necessary for Mr. Baldwin to do much of the work with his own hands, to educate the workmen who assisted him, and to improvise tools for the various processes.

The work was prosecuted, nevertheless, under all these difficulties, and the locomotive was finally completed, christened the "Old Ironsides," and tried on the road, November 23, 1832. The circumstances of the trial are fully preserved, and are given, further on, in the extracts from the journals of the day. Despite some imperfections, naturally occurring in a first effort, and which were afterward, to a great extent, remedied, the engine was, for that early day, a marked and gratifying success. It was put at once into service, as appears from the Company's advertisement three days after the trial, and did duty on the Germantown road and others for over a score of years.

The "Ironsides" was a four-wheeled engine, modeled essentially on the English practice of that day, as shown in the "Planet" class, and weighed, in running order, something over five tons. The rear or driving-wheels were fifty-four inches in diameter on a crank-axle placed in front of the fire-box. The cranks were thirty-nine inches from centre to centre. The front wheels, which were simply carrying wheels, were forty-five inches in diameter, on an axle placed just back of the cylinders. The cylinders were nine and one-half inches in diameter by eighteen inches stroke, and were attached horizontally to the outside of the smoke-box, which was D-shaped, with the sides receding inwardly, so as to bring the centre line of each cylinder in line with the centre of the crank. The wheels were made with heavy cast-iron hubs, wooden spokes and rims, and wrought-iron tires. The frame was of wood, placed outside the wheels. The boiler was thirty inches in diameter, and contained seventy-two copper flues, one and one-half inches in diameter and seven feet long. The tender was a four-wheeled platform, with wooden sides and back, carrying an iron box for a water-tank, inclosed in a wooden casing, and with a space for fuel in front. The engine had no cab. The valve-motion was at first given by a single loose eccentric for each cylinder, placed on the axle between the crank and the hub of the wheel. On the inside of the eccentric was a half-circular slot, running half-way around. A stop was fastened to the axle at the arm of the crank, terminating in a pin which projected into the slot. The engine was reversed by changing the position of the eccentric on the axle by a lever operated from the footboard. This form of valve-motion was, however, shortly afterward changed, and a single fixed eccentric for each cylinder substituted. The rock-shafts, which were under the footboard, had arms above and below, and the eccentric-straps had each a forked rod, with a hook, or an upper

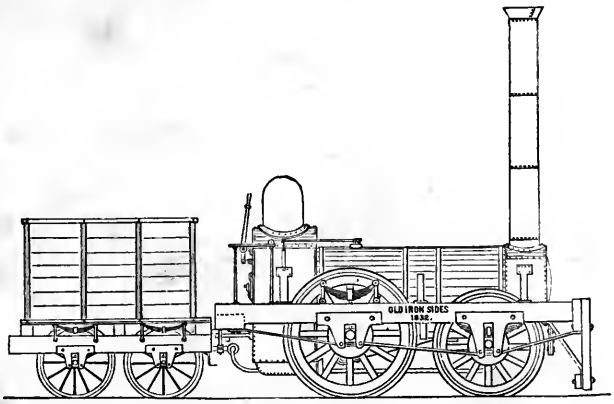


FIG. 1.—THE "OLD IRONSIDES," 1832.

and lower latch or pin, at their extremities, to engage with the upper or lower arm of the rock-shaft. The eccentric-rods were raised or lowered by a double treadle, so as to connect with the upper or lower arm of the rock-shaft, according as forward or backward gear was desired. A peculiarity in the exhaust of the "Ironsides" was that there was only a single straight pipe running across from one cylinder to the other, with an opening in the upper side of the pipe, midway between the cylinders, to which was attached at right angles the perpendicular pipe into the chimney. The cylinders, therefore, exhausted against each other; and it was found, after the engine had been put in use, that this was a serious objection. This defect was afterward remedied by turning each exhaust-pipe upward into the chimney, substantially as is now done. The steam-joints were made with canvas and red-lead, as was the practice in English locomotives, and in consequence much trouble was caused, from time to time, by leaking.

The price of the engine was to have been $4000, but some difficulty was found in procuring a settlement. The Company claimed that the engine did not perform according to contract; and objection was also made to some of the defects alluded to. After these had been corrected as far as possible, however, Mr. Baldwin finally succeeded in effecting a compromise settlement, and received from the Company $3500 for the machine.

The results of the trial and the impression produced by it on the public mind may be gathered from the following extracts from the newspapers of the day:

The *United States Gazette* of November 24, 1832, remarks:

"A most gratifying experiment was made yesterday afternoon on the Philadelphia, Germantown and Norristown Railroad. The beautiful locomotive engine and tender, built by Mr. Baldwin, of this city, whose reputation as an ingenious machinist is well known, were for the first time placed on the road. The engine traveled about six miles, working with perfect accuracy and ease in all its parts, and with great velocity."

The *Chronicle* of the same date noticed the trial more at length, as follows:

"It gives us pleasure to state that the locomotive engine built by our townsman, M. W. Baldwin, has proved highly successful. In the presence of several gentlemen of science and information on such subjects, the engine was yesterday placed upon the road for the first time. All her parts had been previously highly finished and fitted together in Mr. Baldwin's factory. She was taken apart on Tuesday and removed to the Company's depot, and yesterday morning she was completely together, ready for travel. After the regular passenger cars had arrived from Germantown in the afternoon, the tracks being clear, preparation was made for her starting. The placing fire in the furnace and raising steam occupied twenty minutes. The engine (with her tender) moved from the depot in beautiful style, working with great ease and uniformity. She proceeded about half a mile beyond the Union Tavern, at the township line, and returned immediately, a distance of six miles, at a speed of about twenty-eight miles to the hour, her speed having been slackened at all the road crossings, and it being after dark, but a portion of her power was used. It is needless to say that the spectators were delighted. From this experiment there is every reason to believe this engine will draw thirty tons gross, at an average speed of forty miles an hour, on a level road. The principal superiority of the engine over any of the English ones known, consists in the light weight,—which is but between four and five tons,—her small bulk, and the simplicity of her working machinery. We rejoice at the result of this experiment, as it conclusively shows that Philadelphia, always

famous for the skill of her mechanics, is enabled to produce steam-engines for railroads combining so many superior qualities as to warrant the belief that her mechanics will hereafter supply nearly all the public works of this description in the country."

On subsequent trials, the "Ironsides" attained a speed of thirty miles per hour, with its usual train attached. So great were the wonder and curiosity which attached to such a prodigy, that people flocked to see the marvel, and eagerly bought the privilege of riding after the strange monster. The officers of the road were not slow to avail themselves of the public interest to increase their passenger receipts, and the following advertisement from *Poulson's American Daily Advertiser* of November 26, 1832, will show that as yet they regarded the new machine rather as a curiosity and a bait to allure travel than as a practical, every-day servant:

"NOTICE.—The locomotive engine (built by M. W. Baldwin, of this city) will depart daily, *when the weather is fair*, with a train of passenger cars. *On rainy days horses will be attached.*"

This announcement did not mean that in wet weather horses *would be attached to the locomotive* to aid it in drawing the train, but that the usual horse cars would be employed in making the trips upon the road without the engine.

Upon making the first trip to Germantown with a passenger train with the "Ironsides," one driving-wheel slipped upon the axle, causing the wheels to track less than the gauge of the road and drop in between the rails. It was also discovered that the valve arrangement of the pumps was defective, and they failed to supply the boiler with water. The shifting of the driving-wheel upon the axle fastened the eccentric, so that it would not operate in backward motion. These mishaps caused delay, and prevented the engine from reaching its destination, to the great disappointment of all concerned. They were corrected in a few days, and the machine was used in experimenting upon its efficiency, making occasional trips with trains to Germantown. The road had an ascending grade, nearly uniform, of thirty-two feet per mile, and for the last half-mile of forty-five feet per mile, and it was found that the engine was too light for the business of the road upon these grades.

Such was Mr. Baldwin's first locomotive; and it is related of him that his discouragement at the difficulties which he had undergone in building it and in finally procuring a settlement for it was such that he remarked to one of his friends, with much decision, "That is our last locomotive."

It was some time before he received an order for another, but meanwhile the subject had become singularly fascinating to him, and occupied his mind so fully that he was eager to work out his new ideas in a tangible form.

Shortly after the "Ironsides" had been placed on the Germantown road, Mr. E. L. Miller, of Charleston, S. C., came to Philadelphia and made a careful examination of the machine. Mr. Miller had, in 1830, contracted to furnish a locomotive to the Charleston and Hamburg Railroad Company, and accordingly the engine "Best Friend" had been built under his direction at the West Point

Foundry, New York. After inspecting the "Ironsides," he suggested to Mr. Baldwin to visit the Mohawk and Hudson Railroad and examine an English locomotive which had been placed on that road in July, 1831, by Messrs. Robert Stephenson & Co., of Newcastle, England. It was originally a four-wheeled engine of the "Planet" type, with horizontal cylinders and crank-axle. The front wheels of this engine were removed about a year after the machine was put at work, and a four-wheeled swiveling or "bogie" truck substituted. The result of Mr. Baldwin's investigations was the adoption of this design, but with some important improvements. Among these was the "half-crank," which he devised on his return from this trip, and which he patented September 10, 1834. In this form of crank, shown in Figure 2, the outer arm is omitted, and the wrist is fixed in a spoke of the wheel. In other words, the wheel itself formed one arm of the crank. The result sought and gained was that the cranks were strengthened, and, being at the extremities of the axle, the boiler could be made larger in diameter and placed lower. The driving-axle could also be placed back of the fire-box, the connecting rods passing by the sides of the fire-box and taking hold inside of the wheels. This arrangement of the crank also involved the placing of the cylinders outside the smoke-box, as was done on the "Ironsides."

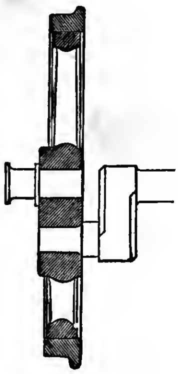


Fig. 2.—Half-Crank.

By the time the order for the second locomotive was received, Mr. Baldwin had matured this device and was prepared to embody it in practical form. The order came from Mr. E. L. Miller in behalf of the Charleston and Hamburg Railroad Company, and the engine bore his name, and was completed February 18, 1834. It was on six wheels; one pair being driving-wheels, four and a half feet in diameter, with half-crank axle placed back of the fire-box as above described, and the four front wheels combined in a swiveling truck. The driving-wheels, it should be observed, were cast in solid bell-metal! The combined wood and iron wheels used on the "Ironsides" had proved objectionable, and Mr. Baldwin, in his endeavors to find a satisfactory substitute, had recourse to brass. June 29, 1833, he took out a patent for a cast-brass wheel, his idea being that by varying the hardness of the metal the adhesion of the wheels on the rails could be increased or diminished at will. The brass wheels on the "Miller," however, soon wore out, and the experiment with this metal was not repeated. The "E. L. Miller" had cylinders ten inches in diameter; stroke of piston, sixteen inches; and weighed, with water in the boiler, seven tons eight hundredweight. The boiler had a high dome over the fire-box, as shown in Figure 3; and this form of construction, it may be noted, was followed, with a few exceptions, for many years.

The valve-motion was given by a single fixed eccentric for each cylinder. Each eccentric-strap had two arms attached to it, one above and the other below, and, as the driving-axle was back of the fire-box, these arms were prolonged backward under the footboard, with a hook on the inner side of the

end of each. The rock-shaft had arms above and below its axis, and the hooks of the two rods of each eccentric were moved by hand-levers so as to engage with either arm, thus producing backward or forward gear. This form of single eccentric, peculiar to Mr. Baldwin, was in the interest of simplicity in the working parts, and was adhered to for some years. It gave rise to an animated controversy among mechanics as to whether, with its use, it was possible to get a lead on the valve in both directions. Many maintained that this was impracticable; but Mr. Baldwin demonstrated by actual experience that the reverse was the case.

Meanwhile the Commonwealth of Pennsylvania had given Mr. Baldwin an order for a locomotive for the State Road, as it was then called, from Philadelphia to Columbia, which, up to that time, had been worked by horses. This engine, called the "Lancaster," was completed in June, 1834. It was similar to the "Miller," and weighed seventeen thousand pounds. After it was placed in service, the records show that it hauled at one time nineteen loaded burden cars over the highest grades between Philadelphia and Columbia. This was characterized at the time by the officers of the road as an "unprecedented performance." The success of the machine on its trial trips was such that the Legislature decided to adopt steam-power for working the road, and Mr. Baldwin received orders for several additional locomotives. Two others were accordingly delivered to the State in September and November respectively of that year, and one was also built and delivered to the Philadelphia and Trenton Railroad Company during the same season. This latter engine, which was put in service October 21, 1834, averaged twenty-one thousand miles per year to September, 15, 1840.

Five locomotives were thus completed in 1834, and the new business was fairly under way. The building in Lodge Alley, to which Mr. Baldwin had removed from Minor Street, and where these engines were constructed, began to be found too contracted, and another removal was decided upon. A location on Broad and Hamilton Streets (the site, in part, of the present works) was selected, and a three-story L-shaped brick building, fronting on both streets, erected. This was completed and the business removed to it during the following year (1835). The original building still stands, forming part of the boiler-shop and machine-shops of the present works.

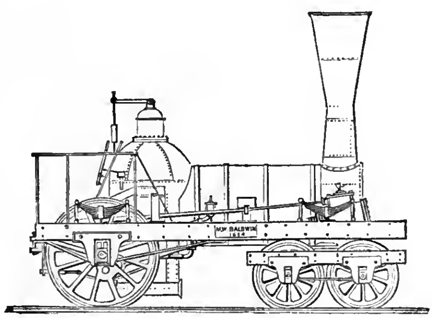


Fig. 3.—Baldwin Engine, 1834.

These early locomotives, built in 1834, were the types of Mr. Baldwin's practice for some years. Their general design is shown in Figure 3. All, or nearly all of them, embraced several important devices, which were the results of his study and experiments up to that time. The devices referred to were patented September 10, 1834, and the same patent covered the four following inventions, viz.:

1. The half-crank, and method of attaching it to the driving-wheel. (This has already been described.)

2. A new mode of constructing the wheels of locomotive engines and cars. In this the hub and spokes were of cast-iron, cast together. The spokes were cast without a rim, and terminated in segment flanges, each spoke having a separate flange disconnected from its neighbors. By this means, it was claimed, the injurious effect of the unequal expansion of the materials composing the wheels was lessened or altogether prevented. The flanges bore against wooden felloes, made in two thicknesses, and put together so as to break joints. Tenons

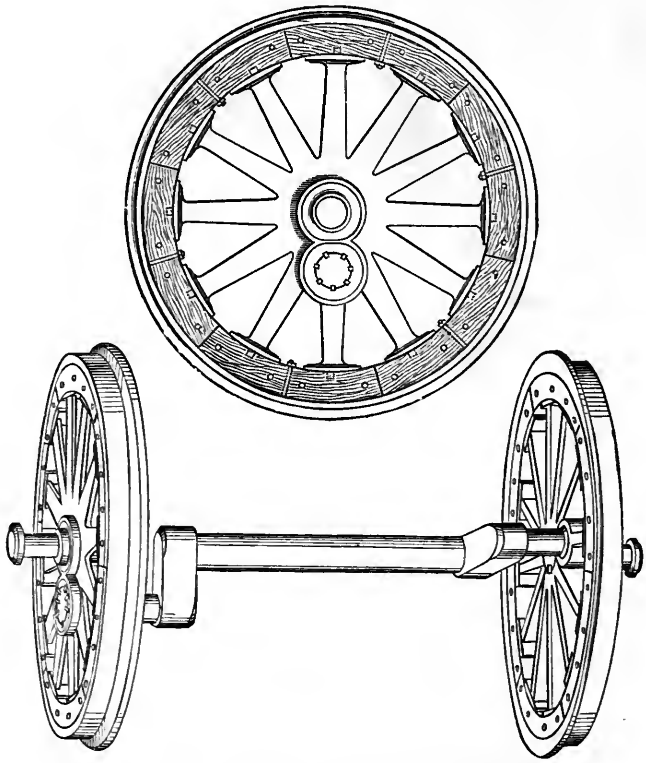


Fig. 4.—Baldwin Compound Wood and Iron Wheels, 1834.

or pins projected from the flanges into openings made in the wooden felloes, to keep them in place. Around the whole the tire was passed and secured by bolts. The above sketch shows the device.

3. A new mode of forming the joints of steam and other tubes. This was Mr. Baldwin's invention of ground joints for steam-pipes, which was a very valuable improvement over previous methods of making joints with red-lead packing, and which rendered it possible to carry a much higher pressure of steam.

4. A new mode of forming the joints and other parts of the supply-pump, and of locating the pump itself. This invention consisted in making the single guide-bar hollow and using it for the pump-barrel. The pump-plunger was

attached to the piston-rod at a socket or sleeve formed for the purpose, and the hollow guide-bar terminated in the vertical pump-chamber. This chamber was made in two pieces, joined about midway between the induction and eduction pipes. This joint was ground steam-tight, as were also the joints of the induction-pipe with the bottom of the lower chamber, and the flange of the eduction-pipe with the top of the upper chamber. All these parts were held together by a stirrup with a set-screw in its arched top, and the arrangement was such that by simply unscrewing this set-screw the different sections of the chamber, with all the valves, could be taken apart for cleaning or adjusting. The cut below illustrates the device.

It is probable that the five engines built during 1834 embodied all, or nearly all, these devices. They all had the half-crank, the ground joints for steam-

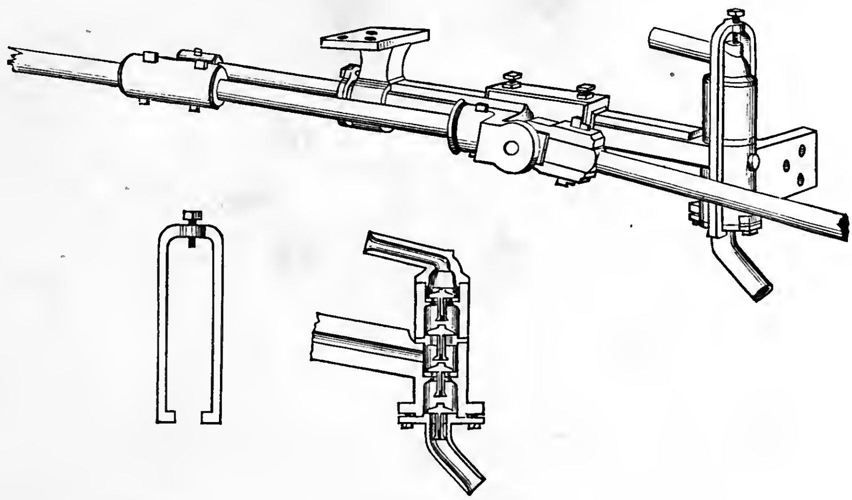


Fig. 5.—Pump and Stirrup.

pipes (which were first made by him in 1833), and the pump formed in the guide-bar, and all had the four-wheeled truck in front, and a single pair of drivers back of the fire-box. On this position of the driving-wheels Mr. Baldwin laid great stress, as it made a more even distribution of the weight, throwing about one-half on the driving-wheels and one-half on the four-wheeled truck. It also extended the wheel-base, making the engine much steadier and less damaging to the track. Mr. William Norris, who had established a locomotive works in Philadelphia in 1832, was at this time building a six-wheeled engine with a truck in front and the driving-wheels placed in front of the fire-box. Considerable rivalry naturally existed between the two manufacturers as to the comparative merits of their respective plans. In Mr. Norris's engine, the position of the driving-axle in front of the fire-box threw on it more of the weight of the engine, and thus increased the adhesion and the tractive power. Mr. Baldwin, however, maintained the superiority of his plan, as giving a better distribution of the weight and a longer wheel-base, and consequently rendering the

machine less destructive to the track. As the iron rails then in use were generally light, and much of the track was of wood, this feature was of some importance.

To the use of the ground joint for steam-pipes, however, much of the success of his early engines was due. The English builders were making locomotives with canvas and red-lead joints, permitting a steam pressure of only sixty pounds per inch to be carried, while Mr. Baldwin's machines were worked at one hundred and twenty pounds with ease. Several locomotives imported from England at about this period by the Commonwealth of Pennsylvania for the State Road (three of which were made by Stephenson) had canvas and red-lead joints, and their efficiency was so much less than that of the Baldwin engines, on account of this and other features of construction, that they were soon laid aside or sold.

In June, 1834, a patent was issued to Mr. E. L. Miller, by whom Mr. Baldwin's second engine was ordered, for a method of increasing the adhesion of a locomotive by throwing a part of the weight of the tender on the rear of the engine, thus increasing the weight on the driving-wheels. Mr. Baldwin adopted this device on an engine built for the Philadelphia and Trenton Railroad Company, May, 1835, and thereafter used it largely, paying one hundred dollars royalty for each engine. Eventually (May 6, 1839) he bought the patent for nine thousand dollars, evidently considering that the device was especially valuable, if not indispensable, in order to render his engine as powerful, when required, as other patterns having the driving-wheels in front of the fire-box, and therefore utilizing more of the weight of the engine for adhesion.

In making the truck and tender-wheels of these early locomotives, the hubs were cast in three pieces and afterwards banded with wrought-iron, the interstices being filled with spelter. This method of construction was adopted on account of the difficulty then found in casting a chilled wheel in one solid piece.

Early in 1835, the new shop on Broad Street was completed and occupied. Mr. Baldwin's attention was thenceforward given to locomotive building exclusively, except that a stationary engine was occasionally constructed.

In May, 1835, his eleventh locomotive, the "Black Hawk," was delivered to the Philadelphia and Trenton Railroad Company. This was the first outside-connected engine of his build. It was also the first engine on which the Miller device of attaching part of the weight of the tender to the engine was employed. On the eighteenth engine, the "Brandywine," built for the Philadelphia and Columbia Railroad Company, brass tires were used on the driving-wheels, for the purpose of obtaining more adhesion; but they wore out rapidly and were replaced with iron.

April 3, 1835, Mr. Baldwin took out a patent for certain improvements in the wheels and tubes of locomotive engines. That relating to the wheels provided for casting the hub and spokes together, and having the spokes terminate in segments of a rim, as described in his patent of September 10, 1834. Between the ends of the spokes and the tires wood was interposed, and the tire might be

either of wrought-iron or of chilled cast-iron. The intention was expressed of making the tire usually of cast-iron chilled. The main object, however, was declared to be the interposition between the spokes and the rim of a layer of wood or other substance possessing some degree of elasticity. This method of making driving-wheels was followed for several years, and is shown by Figure 6. The tires were made with a shoulder, as shown on a larger scale in Figure 7.

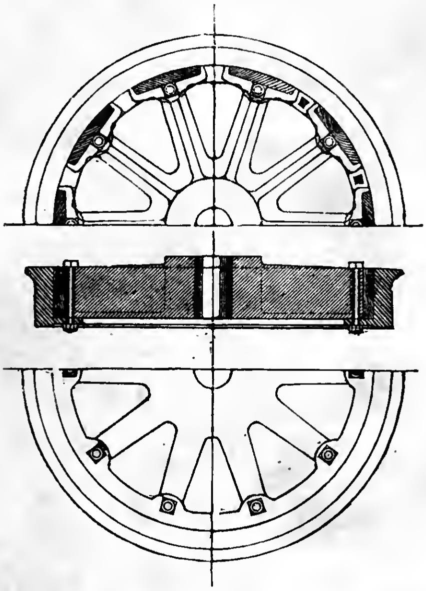


Fig. 6.

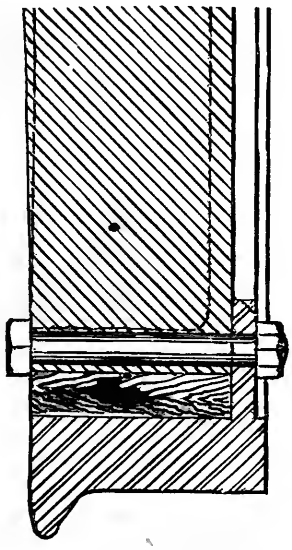


Fig. 7.

The improvement in locomotive tubes consisted in driving a copper ferrule or thimble on the outside of the end of the tube, and soldering it in place, instead of driving a ferrule into the tube, as had previously been the practice. The object of the latter method had been to make a tight joint with the tube-sheet; but by putting the ferrule on the outside of the tube, not only was the joint made as tight as before, but the tube was strengthened, and left unobstructed throughout to the full extent of its diameter. This method of setting flues has been generally followed in the works from that date to the present, the only difference being that, at this time, with iron tubes, the end is swedged down, the copper ferrule brazed on, and the iron end turned or riveted over against the copper thimble and the flue-sheet, to make the joint perfect.

Fourteen engines were constructed in 1835; forty in 1836; forty in 1837; twenty-three in 1838; twenty-six in 1839; and nine in 1840. During all these years the general design continued the same; but, in compliance with the demand for more power, three sizes were furnished, as follows:

First-class.	Cylinders,	$12\frac{1}{2} \times 16$;	weight,	loaded,	26,000	pounds.
Second-class.	"	12×16;	"	"	23,000	"
Third-class.	"	$10\frac{1}{2} \times 16$;	"	"	20,000	"

machine less destructive to the track. As the iron rails then in use were generally light, and much of the track was of wood, this feature was of some importance.

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In making the truck and tender-wheels of these early locomotives, the hubs were cast in three pieces and afterwards banded with wrought-iron, the interstices being filled with spelter. This method of construction was adopted on account of the difficulty then found in casting a chilled wheel in one solid piece.

Early in 1835, the new shop on Broad Street was completed and occupied. Mr. Baldwin's attention was thenceforward given to locomotive building exclusively, except that a stationary engine was occasionally constructed.

In May, 1835, his eleventh locomotive, the "Black Hawk," was delivered to the Philadelphia and Trenton Railroad Company. This was the first outside-connected engine of his build. It was also the first engine on which the Miller device of attaching part of the weight of the tender to the engine was employed. On the eighteenth engine, the "Brandywine," built for the Philadelphia and Columbia Railroad Company, brass tires were used on the driving-wheels, for the purpose of obtaining more adhesion; but they wore out rapidly and were replaced with iron.

April 3, 1835, Mr. Baldwin took out a patent for certain improvements in the wheels and tubes of locomotive engines. That relating to the wheels provided for casting the hub and spokes together, and having the spokes terminate in segments of a rim, as described in his patent of September 10, 1834. Between the ends of the spokes and the tires wood was interposed, and the tire might be

either of wrought-iron or of chilled cast-iron. The intention was expressed of making the tire usually of cast-iron chilled. The main object, however, was declared to be the interposition between the spokes and the rim of a layer of wood or other substance possessing some degree of elasticity. This method of making driving-wheels was followed for several years, and is shown by Figure 6. The tires were made with a shoulder, as shown on a larger scale in Figure 7.

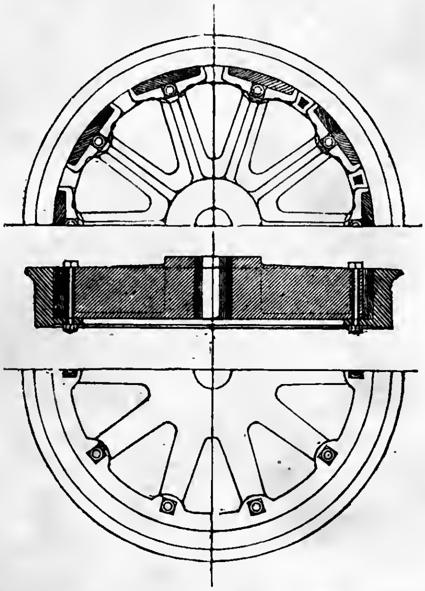


Fig. 6.

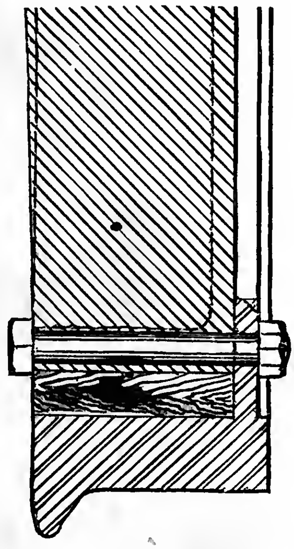


Fig. 7.

The improvement in locomotive tubes consisted in driving a copper ferrule or thimble on the outside of the end of the tube, and soldering it in place, instead of driving a ferrule into the tube, as had previously been the practice. The object of the latter method had been to make a tight joint with the tube-sheet; but by putting the ferrule on the outside of the tube, not only was the joint made as tight as before, but the tube was strengthened, and left unobstructed throughout to the full extent of its diameter. This method of setting flues has been generally followed in the works from that date to the present, the only difference being that, at this time, with iron tubes, the end is swedged down, the copper ferrule brazed on, and the iron end turned or riveted over against the copper thimble and the flue-sheet, to make the joint perfect.

Fourteen engines were constructed in 1835; forty in 1836; forty in 1837; twenty-three in 1838; twenty-six in 1839; and nine in 1840. During all these years the general design continued the same; but, in compliance with the demand for more power, three sizes were furnished, as follows:

First-class.	Cylinders,	12½ × 16;	weight, loaded,	26,000 pounds.
Second-class.	"	12 × 16;	" "	23,000 "
Third-class.	"	10½ × 16;	" "	20,000 "

wooden frame was abandoned, and no outside frame whatever was employed,—the machinery, as well as the truck and the pedestals of the driving-axles, being attached directly to the naked boiler. The wooden frame thenceforward disappeared gradually, and an iron frame took its place. Another innovation was the adoption of eight-wheeled tenders, the first of which was built at about this period.

April 8, 1839, Mr. Baldwin associated with himself Messrs. Vail and Hufty, and the business was conducted under the firm name of Baldwin, Vail & Hufty until 1841, when Mr. Hufty withdrew, and Baldwin & Vail continued the copartnership until 1842.

The time had now arrived when the increase of business on railroads demanded more powerful locomotives. It had for some years been felt that for freight traffic the engine with one pair of driving-wheels was insufficient. Mr. Baldwin's engine had the single pair of driving-wheels placed back of the fire-box; that made by Mr. Norris, one pair in front of the fire-box. An engine with two pairs of driving-wheels, one pair in front and one pair behind the fire-box, was the next logical step, and Mr. Henry R. Campbell, of Philadelphia, was the first to carry this design into execution. Mr. Campbell, as has been noted, was the Chief Engineer of the Germantown Railroad when the "Ironsides" was placed on that line, and had since given much attention to the subject of locomotive construction. February 5, 1836, Mr. Campbell secured a patent for an eight-wheeled engine with four driving-wheels connected, and a four-wheeled truck in front; and subsequently contracted with James Brooks, of Philadelphia, to build for him such a machine. The work was begun March 16, 1836, and the engine was completed May 8, 1837. This was the first eight-wheeled engine of this type, and from it the standard American locomotive of to-day takes its origin. The engine lacked, however, one essential feature; there were no equalizing beams between the driving-wheels, and nothing but the ordinary steel springs over each journal of the driving-axles to equalize the weight upon them. It remained for Messrs. Eastwick & Harrison to supply this deficiency; and in 1837 that firm constructed at their shop in Philadelphia a locomotive on this plan, but with the driving-axles running in a separate square frame, connected to the main frame above it by a single central bearing on each side. This engine had cylinders twelve by eighteen, four coupled driving-wheels, forty-four inches in diameter, carrying eight of the twelve tons constituting the total weight. Subsequently, Mr. Joseph Harrison, Jr., of the same firm, substituted "equalizing beams" on engines of this plan afterward constructed by them, substantially in the same manner as since generally employed.

In the *American Railroad Journal* of July 30, 1836, a woodcut showing Mr. Campbell's engine, together with an elaborate calculation of the effective power of an engine on this plan, by William J. Lewis, Esq., Civil Engineer, was published, with a table showing its performance upon grades ranging from a dead level to a rise of one hundred feet per mile. Mr. Campbell stated that his experience at that time (1835–6) convinced him that grades of one hundred feet rise per mile would, if roads were judiciously located, carry railroads over any

of the mountain passes in America, without the use of planes with stationary steam power, or, as a general rule, of costly tunnels,—an opinion very extensively verified by the experience of the country since that date.

A step had thus been taken toward a plan of locomotive having more adhesive power. Mr. Baldwin, however, was slow to adopt the new design. He naturally regarded innovations with distrust. He had done much to perfect the old pattern of engine, and had built over a hundred of them, which were in successful operation on various railroads. Many of the details were the subjects of his several patents, and had been greatly simplified in his practice. In fact, simplicity in all the working parts had been so largely his aim, that it was natural that he should distrust any plan involving additional machinery, and he regarded the new design as only an experiment at best. In November, 1838, he wrote to a correspondent that he did not think there was any advantage in the eight-wheeled engine. There being three points in contact, it could not turn a curve, he argued, without slipping one or the other pair of wheels sideways. Another objection was in the multiplicity of machinery and the difficulty in maintaining four driving-wheels all of exactly the same size. Some means, however, of getting more adhesion must be had, and the result of his reflections upon this subject was the project of a "geared engine." In August, 1839, he took steps to secure a patent for such a machine, and December 31, 1840, letters patent were granted him for the device. In this engine, an independent shaft or axle was placed between the two axles of the truck, and connected by cranks and coupling-rods with cranks on the outside of the driving-wheels. This shaft had a central cog-wheel engaging on each side with intermediate cog-wheels, which in turn geared into cog-wheels on each truck-axle. The intermediate cog-wheels had wide teeth, so that the truck could pivot while the main shaft remained parallel with the driving-axle. The diameters of the cog-wheels were, of course, in such proportion to the driving and truck-wheels, that the latter should revolve as much oftener than the driving-wheels as their smaller size might require. Of the success of this machine for freight service, Mr. Baldwin was very sanguine. One was put in hand at once, completed in August, 1841, and eventually sold to the Sugarloaf Coal Company. It was an outside-connected engine, weighing thirty thousand pounds, of which eleven thousand seven hundred and seventy-five pounds were on the driving-wheels, and eighteen thousand three hundred and thirty-five on the truck. The driving-wheels were forty-four and the truck-wheels thirty-three inches in diameter. The cylinders were thirteen inches in diameter by sixteen inches stroke. On a trial of the engine upon the Philadelphia and Reading Railroad, it hauled five hundred and ninety tons from Reading to Philadelphia—a distance of fifty-four miles—in five hours and twenty-two minutes. The Superintendent of the road, in writing of the trial, remarked that this train was unprecedented in length and weight both in America and Europe. The performance was noticed in favorable terms by the Philadelphia newspapers, and was made the subject of a report by the Committee on Science and Arts of the Franklin Institute, who strongly recommended this plan of engine for freight

service. The success of the trial led Mr. Baldwin at first to believe that the geared engine would be generally adopted for freight traffic; but in this he was disappointed. No further demand was made for such machines, and no more of them were built.

In 1840, Mr. Baldwin received an order, through August Belmont, Esq., of New York, for a locomotive for Austria, and had nearly completed one which was calculated to do the work required, when he learned that only sixty pounds pressure of steam was admissible, whereas his engine was designed to use steam at one hundred pounds and over. He accordingly constructed another, meeting this requirement, and shipped it in the following year. This engine, it may be noted, had a kind of link-motion, agreeably to the specification received, and was the first of his make upon which the link was introduced.

Mr. Baldwin's patent of December 31, 1840, already referred to as covering his geared engine, embraced several other devices, as follows:

1. A method of operating a fan, or blowing-wheel, for the purpose of blowing the fire. The fan was to be placed under the footboard, and driven by the friction of a grooved pulley in contact with the flange of the driving-wheel.

2. The substitution of a metallic stuffing, consisting of wire, for the hemp, wool, or other material which had been employed in stuffing-boxes.

3. The placing of the springs of the engine truck so as to obviate the evil of the locking of the wheels when the truck-frame vibrates from the centre-pin vertically. Spiral as well as semi-elliptic springs, placed at each end of the truck-frame, were specified. The spiral spring is described as received in two cups,—one above and one below. The cups were connected together at their centres by a pin upon one and a socket in the other, so that the cups could approach toward or recede from each other and still preserve their parallelism.

4. An improvement in the manner of constructing the iron frames of locomotives, by making the pedestals in one piece with, and constituting part of, the frames.

5. The employment of spiral springs in connection with cylindrical pedestals and boxes. A single spiral was at first used, but not proving sufficiently strong, a combination or nest of spirals curving alternately in opposite directions was afterward employed. Each spiral had its bearing in a spiral recess in the pedestal.

In the specification of this patent a change in the method of making cylindrical pedestals and boxes is noted. Instead of boring and turning them in a lathe, they were cast to the required shape in chills. This method of construction was used for a time, but eventually a return was made to the original plan, as giving a more accurate job.

In 1842, Mr. Baldwin constructed, under an arrangement with Mr. Ross Winans, three locomotives for the Western Railroad of Massachusetts, on a plan which had been designed by that gentleman for freight traffic. These machines had upright boilers, and horizontal cylinders which worked cranks on a shaft bearing cog-wheels engaging with other cog-wheels on an intermediate shaft. This latter shaft had cranks coupled to four driving-wheels on each side. These

engines were constructed to burn anthracite coal. Their peculiarly uncouth appearance earned for them the name of "crabs," and they were but short-lived in service.

But, to return to the progress of Mr. Baldwin's locomotive practice. The geared engine had not proved a success. It was unsatisfactory, as well to its designer as to the railroad community. The problem of utilizing more or all of the weight of the engine for adhesion remained, in Mr. Baldwin's view, yet to be solved. The plan of coupling four or six wheels had long before been adopted in England, but on the short curves prevalent on American railroads, he felt that something more was necessary. The wheels must not only be coupled, but at the same time must be free to adapt themselves to a curve. These two conditions were apparently incompatible, and to reconcile these inconsistencies was the task which Mr. Baldwin set himself to accomplish. He undertook it, too, at a time when his business had fallen off greatly and he was involved in the most serious financial embarrassments. The problem was constantly before him, and at length, during a sleepless night, its solution flashed across his mind. The plan so long sought for, and which, subsequently, more than any other of his improvements or inventions, contributed to the foundation of his fortune, was his well-known six-wheels-connected locomotive with the four front driving-wheels combined in a flexible truck. For this machine Mr. Baldwin secured a patent, August 25, 1842. Its principal characteristic features are now matters of history, but they deserve here a brief mention. The engine was on six wheels, all connected. The rear wheels were placed rigidly in the frames, usually behind the fire-box, with inside bearings. The cylinders were inclined, and with outside connections. The four remaining wheels had inside journals running in boxes held by two wide and deep wrought-iron beams, one on each side. These beams

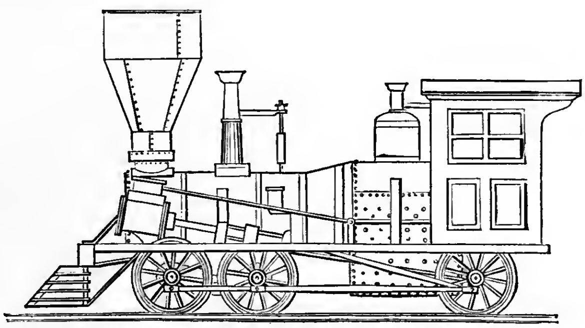


Fig. 8.—Baldwin Six-Wheels-Connected Engine, 1842.

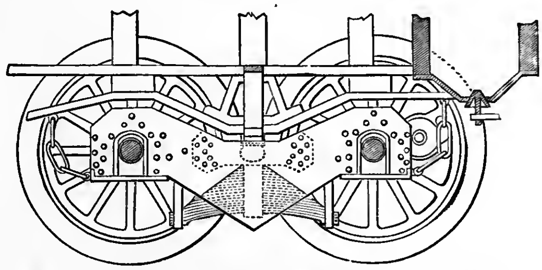
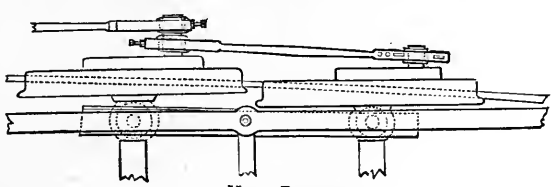


Fig. 9.—Baldwin Flexible-Beam Truck, 1842.—Elevation.



Half Plan.

were unconnected, and entirely independent of each other. The pedestals formed in them were bored out cylindrically, and into them cylindrical boxes, as patented by him in 1835, were fitted. The engine frame on each side was directly over the beam, and a spherical pin, running down from the frame, bore in a socket in the beam midway between the two axles. It will thus be seen that each side-beam independently could turn horizontally or vertically under the spherical pin, and the cylindrical boxes could also turn in the pedestals. Hence, in passing a curve, the middle pair of drivers could move laterally in one direction—say to the right—while the front pair could move in the opposite direction, or to the left; the two axles all the while remaining parallel to each other and to the rear driving-axle. The operation of these beams was, therefore, like that of the parallel-ruler. On a straight line the two beams and the two axles formed a rectangle; on curves, a parallelogram, the angles varying with the degree of curvature. The coupling-rods were made with cylindrical brasses, thus forming ball-and-socket joints, to enable them to accommodate themselves to the lateral movements of the wheels. Colburn, in his "Locomotive Engineering," remarks of this arrangement of rods as follows:

> "Geometrically, no doubt, this combination of wheels could only work properly around curves by a lengthening and shortening of the rods which served to couple the principal pair of driving-wheels with the hind truck-wheels. But if the coupling-rods from the principal pair of driving-wheels be five feet long, and if the beams of the truck-frame be four feet long (the radius of curve described by the axle-boxes around the spherical side bearings being two feet), then the total corresponding lengthening of the coupling-rods, in order to allow the hind truck-wheels to move one inch to one side, and the front wheels of the truck one inch to the other side, of their normal position on a straight line, would be $\sqrt{60^2 + 1^2} - 60 + 24 - \sqrt{24^2 - 1^2} = 0.0275$ inch, or less than one thirty-second of an inch. And if only one pair of driving-wheels were thus coupled with a four-wheeled truck, the total wheel base being nine feet, the motion permitted by this slight elongation of the coupling-rods (an elongation provided for by a trifling slackness in the brasses) would enable three pairs of wheels to stand without binding in a curve of only one hundred feet radius."

The first engine of the new plan was finished early in December, 1842, being one of fourteen engines constructed in that year, and was sent to the Georgia Railroad, on the order of Mr. J. Edgar Thomson, then Chief Engineer and Superintendent of that line. It weighed twelve tons, and drew, besides its own weight, two hundred and fifty tons up a grade of thirty-six feet to the mile.

Other orders soon followed. The new machine was received generally with great favor. The loads hauled by it exceeded anything so far known in American railroad practice, and sagacious managers hailed it as a means of largely reducing operating expenses. On the Central Railroad of Georgia, one of these twelve-ton engines drew nineteen eight-wheeled cars, with seven hundred and fifty bales of cotton, each bale weighing four hundred and fifty pounds, over maximum grades of thirty feet per mile, and the manager of the road declared that it could readily take one thousand bales. On the Philadelphia and Reading Railroad a similar engine of eighteen tons weight drew one hundred and fifty

loaded cars (total weight of cars and lading, one thousand one hundred and thirty tons) from Schuylkill Haven to Philadelphia, at a speed of seven miles per hour. The regular load was one hundred loaded cars, which were hauled at a speed of from twelve to fifteen miles per hour on a level.

The following extract from a letter, dated August 10, 1844, of Mr. G. A. Nicolls, then superintendent of that line, gives the particulars of the performance of these machines, and shows the estimation in which they were held:

"We have had two of these engines in operation for about four weeks. Each engine weighs about forty thousand pounds with water and fuel, equally distributed on six wheels, all of which are coupled, thus gaining the whole adhesion of the engine's weight. Their cylinders are fifteen by eighteen inches.

"The daily allotted load of each of these engines is one hundred coal cars, each loaded with three and six-tenths tons of coal, and weighing two and fifteen one-hundredths tons each, empty; making a net weight of three hundred and sixty tons of coal carried, and a gross weight of train of five hundred and seventy-five tons, all of two thousand two hundred and forty pounds.

"This train is hauled over the ninety-four miles of the road, half of which is level, at the rate of twelve miles per hour; and with it the engine is able to make fourteen to fifteen miles per hour on a level.

"Were all the cars on the road of sufficient strength, and making the trip by daylight, nearly one-half being now performed at night, I have no doubt of these engines being quite equal to a load of eight hundred tons gross, as their average daily performance on any of the levels of our road, some of which are eight miles long.

"In strength of make, quality of workmanship, finish, and proportion of parts, I consider them equal to any, and superior to most, freight engines I have seen. They are remarkably easy on the rail, either in their vertical or horizontal action, from the equalization of their weight, and the improved truck under the forward part of the engine. This latter adapts itself to all the curves of the road, including some of seven hundred and sixteen feet radius in the main track, and moves with great ease around our turning Y curves at Richmond, of about three hundred feet radius.

"I consider these engines as near perfection, in the arrangement of their parts, and their general efficiency, as the present improvements in machinery and the locomotive engine will admit of. They are saving us thirty per cent. in every trip on the former cost of motive or engine power."

But the flexible-beam truck also enabled Mr. Baldwin to supply an engine with four driving-wheels connected. Other builders were making engines with four driving-wheels and a four-wheeled truck, of the present American standard type. To compete with this design, Mr. Baldwin modified his six-wheels-connected engine by connecting only two out of the three pairs of wheels, making the forward wheels of smaller diameter as leading wheels, but combining them with the front driving-wheels in a flexible beam-truck. The first engine on this plan was sent to the Erie and Kalamazoo Railroad, in October, 1843, and gave great satisfaction. The Superintendent of the road was enthusiastic in its praise, and wrote to Mr. Baldwin that he doubted "if anything could be got up which would answer the business of the road so well." One was also sent to the Utica and Schenectady Railroad a few weeks later, of which the Superintendent

remarked that "it worked beautifully, and there were not wagons enough to give it a full load." In this plan the leading wheels were usually made thirty-six and the driving-wheels fifty-four inches in diameter.

This machine of course came in competition with the eight-wheeled engine having four driving-wheels, and Mr. Baldwin claimed for his plan a decided superiority. In each case about two-thirds of the total weight was carried on the four driving-wheels, and Mr. Baldwin maintained that his engine, having only six instead of eight wheels, was simpler and more effective.

At about this period Mr. Baldwin's attention was called by Mr. Levi Bissell to an "Air Spring" which the latter had devised, and which it was imagined was destined to be a cheap, effective, and perpetual spring. The device consisted of a small cylinder placed above the frame over the axle-box, and having a piston fitted air-tight into it. The piston-rod was to bear on the axle-box, and the proper quantity of air was to be pumped into the cylinder above the piston, and the cylinder then hermetically closed. The piston had a leather packing which was to be kept moist by some fluid (molasses was proposed) previously introduced into the cylinder. Mr. Baldwin at first proposed to equalize the weight between two pairs of drivers by connecting two air-springs on each side by a pipe, the use of an equalizing beam being covered by Messrs. Eastwick & Harrison's patent. The air-springs were found, however, not to work practically, and were never applied. It may be added that a model of an equalizing air-spring was exhibited by Mr. Joseph Harrison, Jr., at the Franklin Institute, in 1838 or 1839.

With the introduction of the new machine, business began at once to revive and the tide of prosperity turned once more in Mr. Baldwin's favor. Twelve engines were constructed in 1843, all but four of them of the new pattern; twenty-two engines in 1844, all of the new pattern; and twenty-seven in 1845. Three of this number were of the old type, with one pair of driving-wheels, but from that time forward the old pattern with the single pair of driving-wheels disappeared from the practice of the establishment, save occasionally for exceptional purposes.

In 1842, the partnership with Mr. Vail was dissolved, and Mr. Asa Whitney, who had been Superintendent of the Mohawk and Hudson Railroad, became a partner with Mr. Baldwin, and the firm continued as Baldwin & Whitney until 1846, when the latter withdrew to engage in the manufacture of car-wheels, establishing the firm of A. Whitney & Sons, Philadelphia.

Mr. Whitney brought to the firm a railroad experience and thorough business talent. He introduced a system in many details of the management of the business, which Mr. Baldwin, whose mind was devoted more exclusively to mechanical subjects, had failed to establish or wholly ignored. The method at present in use in the establishment, of giving to each class of locomotives a distinctive designation, composed of a number and a letter, originated very shortly after Mr. Whitney's connection with the business. For the purpose of representing the different designs, sheets with engravings of locomotives were employed. The sheet showing the engine with one pair of driving-wheels was marked B;

that with two pairs, C; that with three, D; and that with four, E. Taking its rise from this circumstance, it became customary to designate as B engines those with one pair of driving-wheels; as C engines, those with two pairs; as D engines, those with three pairs; and as E engines, those with four pairs. Shortly afterwards a number, indicating the weight in gross tons, was added. Thus, the 12 D engine was one with three pairs of driving-wheels, and weighing twelve tons; the 12 C, an engine of same weight, but with only four wheels connected. A modification of this method of designating the several plans and sizes is still in use, and is explained elsewhere.

It will be observed that the classification as thus established began with the B engines. The letter A was reserved for an engine intended to run at very high speeds, and so designed that the driving-wheels should make two revolutions for each reciprocation of the pistons. This was to be accomplished by means of gearing. The general plan of the engine was determined in Mr. Baldwin's mind, but was never carried into execution.

The adoption of the plan of six-wheels-connected engines opened the way at once to increasing their size. The weight being almost evenly distributed on six points, heavier machines were admissible, the weight on any one pair of driving-wheels being little, if any, greater than had been the practice with the old plan of engine having a single pair of driving-wheels. Hence engines of eighteen and twenty tons weight were shortly introduced, and in 1844 three of twenty tons weight, with cylinders sixteen and one-half inches diameter by eighteen inches stroke, were constructed for the Western Railroad of Massachusetts, and six of eighteen tons weight, with cylinders fifteen by eighteen, and driving-wheels forty-six inches in diameter, were built for the Philadelphia and Reading Railroad. It should be noted that three of these latter engines had iron flues. This was the first instance in which Mr. Baldwin had employed tubes of this material, although they had been previously used by others. Lap-welded iron flues were made by Morris, Tasker & Co., of Philadelphia, about 1838, and but-welded iron tubes had previously been made by the same firm. Ross Winans, of Baltimore, had also made iron tubes by hand for locomotives of his manufacture before 1838. The advantage found to result from the use of iron tubes, apart from their less cost, was that the tubes and boiler-shell, being of the same material, expanded and contracted alike, while in the case of copper tubes the expansion of the metal by heat varied from that of the boiler-shell, and as a consequence there was greater liability to leakage at the joints with the tube-sheets. The opinion prevailed largely at that time that some advantage resulted in the evaporation of water, owing to the superiority of copper as a conductor of heat. To determine this question, an experiment was tried with two of the six engines referred to above, one of which, the "Ontario," had copper flues, and another, the "New England," iron flues. In other respects they were precisely alike. The two engines were run from Richmond to Mount Carbon, August 27, 1844, each drawing a train of one hundred and one empty cars, and, returning, from Mount Carbon to Richmond, on the following day, each with one hundred loaded cars. The quantity

of water evaporated and wood consumed was noted, with the result shown in the following table:

	Up Trip, Aug. 27, 1844.		Down Trip, Aug. 28, 1844.	
	"Ontario." (Copper Flues.)	"New England." (Iron Flues.)	"Ontario." (Copper Flues.)	"New England." (Iron Flues.)
Time, running	9h. 7m.	7h. 41m.	10h. 44m.	8h. 19m.
" standing at stations	4h. 2m.	3h. 7m.	2h. 12m.	3h. 8m.
Cords of wood burned	6.68	5.50	6.94	6.
Cubic feet of water evaporated	925.75	757.26	837.46	656.39
Ratio, cubic feet of water to a cord of wood	138.57	137.68	120.67	109.39

The conditions of the experiments not being absolutely the same in each case, the results could not of course be accepted as entirely accurate. They seemed to show, however, no considerable difference in the evaporative efficacy of copper and iron tubes.

The period under consideration was marked also by the introduction of the French & Baird stack, which proved at once to be one of the most successful spark-arresters thus far employed, and which was for years used almost exclusively wherever, as on the cotton-carrying railroads of the South, a thoroughly effective spark-arrester was required. This stack was introduced by Mr. Baird, then a foreman in the works, who purchased the patent-right of what had been known as the Grimes stack, and combined with it some of the features of the stack made by Mr. Richard French, then Master Mechanic of the Germantown Railroad, together with certain improvements of his own. The cone over the straight inside pipe was made with volute flanges on its under side, which gave a rotary motion to the sparks. Around the cone was a casing about six inches smaller in diameter than the outside stack. Apertures were cut in the sides of this casing, through which the sparks in their rotary motion were discharged, and thus fell to the bottom of the space between the straight inside pipe and the outside stack. The opening in the top of the stack was fitted with a series of V-shaped iron circles perforated with numerous holes, thus presenting an enlarged area, through which the smoke escaped. The patent-right for this stack was subsequently sold to Messrs. Radley & Hunter, and its essential principle is still used in the Radley & Hunter stack as at present made.

In 1845, Mr. Baldwin built three locomotives for the Royal Railroad Committee of Würtemberg. They were of fifteen tons weight, on six wheels, four of them being sixty inches in diameter and coupled. The front driving-wheels were combined by the flexible beams into a truck with the smaller leading wheels. The cylinders were inclined and outside, and the connecting-rods took hold of a half-crank axle back of the fire-box. It was specified that these engines should have the link-motion which had shortly before been introduced in England by the Stephensons. Mr. Baldwin accordingly applied a link of a peculiar character

to suit his own ideas of the device. The link was made solid, and of a truncated V-section, and the block was grooved so as to fit and slide on the outside of the link.

During the year 1845 another important feature in locomotive construction—the cut-off valve—was added to Mr. Baldwin's practice. Up to that time the valve-motion had been the two eccentrics, with the single flat hook for each cylinder. Since 1841, Mr. Baldwin had contemplated the addition of some device allowing the steam to be used expansively, and he now added the "half-stroke cut-off." In this device the steam-chest was separated by a horizontal plate into an upper and a lower compartment. In the upper compartment, a valve, worked by a separate eccentric, and having a single opening, admitted steam through a port in this plate to the lower steam-chamber. The valve-rod of the upper valve terminated in a notch or hook, which engaged with the upper arm of its rock-shaft. When thus working, it acted as a cut-off at a fixed part of the stroke, determined by the setting of the eccentric. This was usually at half the stroke. When it was desired to dispense with the cut-off and work steam for the full stroke, the hook of the valve-rod was lifted from the pin on the upper arm of the rock-shaft by a lever worked from the footboard, and the valve-rod was held in a notched rest fastened to the side of the boiler. This left the opening through the upper valve and the port in the partition plate open for the free passage of steam throughout the whole stroke. The first application of the half-stroke cut-off was made on the engine "Champlain" (20 D), built for the Philadelphia and Reading Railroad Company, in 1845. It at once became the practice to apply the cut-off on all passenger engines, while the six- and eight-wheels-connected freight engines were, with a few exceptions, built for a time longer with the single valve admitting steam for the full stroke.

After building, during the years 1843, 1844, and 1845, ten four-wheels-connected engines on the plan above described, viz., six wheels in all, the leading wheels and the front driving-wheels being combined into a truck by the flexible beams, Mr. Baldwin finally adopted the present design of four driving-wheels and a four-wheeled truck. Some of his customers who were favorable to the latter plan had ordered such machines of other builders, and Colonel Gadsden, President of the South Carolina Railroad Company, called on him in 1845 to build for that line some passenger engines of this pattern. He accordingly bought the patent-right for this plan of engine of Mr. H. R. Campbell, and for the equalizing beams used between the driving-wheels, of Messrs. Eastwick & Harrison, and delivered to the South Carolina Railroad Company, in December, 1845, his first eight-wheeled engine with four driving-wheels and a four-wheeled truck. This machine had cylinders thirteen and three-quarters by eighteen, and driving-wheels sixty inches in diameter, with the springs between them arranged as equalizers. Its weight was fifteen tons. It had the half-crank axle, the cylinders being inside the frame but outside the smoke-box. The inside-connected engine, counterweighting being as yet unknown, was admitted to be steadier in running, and hence more suituable for passenger service. With the completion of the

first eight-wheeled "C" engine, Mr. Baldwin's feelings underwent a revulsion in favor of this plan, and his partiality for it became as great as had been his antipathy before. Commenting on the machine, he recorded himself as "more pleased with its appearance and action than any engine he had turned out." In addition to the three engines of this description for the South Carolina Railroad Company, a duplicate was sent to the Camden and Amboy Railroad Company, and a similar but lighter one to the Wilmington and Baltimore Railroad Company, shortly afterwards. The engine for the Camden and Amboy Railroad Company, and perhaps the others, had the half-stroke cut-off.

From that time forward all of his four-wheels-connected machines were built on this plan, and the six-wheeled "C" engine was abandoned, except in the case of one built for the Philadelphia, Germantown and Norristown Railroad Company in 1846, and this was afterwards rebuilt into a six-wheels-connected machine. Three methods of carrying out the general design were, however, subsequently followed. At first the half-crank was used; then horizontal cylinders inclosed in the chimney-seat and working a full-crank axle, which form of construction had been practiced at the Lowell Works; and eventually, outside cylinders with outside connections.

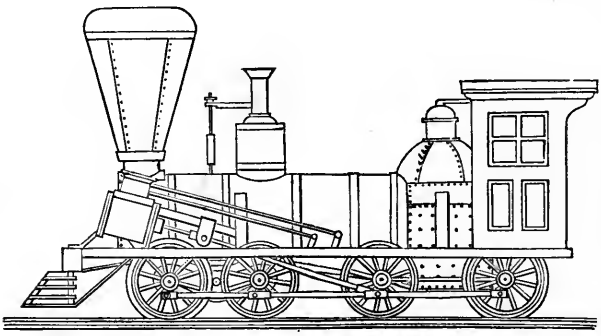


Fig. 10.—Baldwin Eight-Wheels-Connected Engine, 1846.

Meanwhile the flexible truck machine maintained its popularity for heavy freight service. All the engines thus far built on this plan had been six-wheeled, some with the rear driving-axle back of the fire-box, and others with it in front. The next step, following logically after the adoption of the eight-wheeled "C" engine, was to increase the size of the freight machine, and distribute the weight on eight wheels all connected, the two rear pairs being rigid in the frame, and the two front pairs combined into the flexible-beam truck. This was first done in 1846, when seventeen engines on this plan were constructed on one order for the Philadelphia and Reading Railroad Company. Fifteen of these were of twenty tons weight, with cylinders fifteen and a half by twenty, and wheels forty-six inches in diameter; and two of twenty-five tons weight, with cylinders seventeen and a quarter by eighteen, and wheels forty-two inches in diameter. These engines were the first ones on which Mr. Baldwin placed sand-boxes, and they were also the first built by him with roofs. On all previous engines the footboard had only been inclosed by a railing. On these engines for the Reading Railroad four iron posts were carried up, and a wooden roof supported by them. The engine-men added curtains at the sides and front, and Mr. Baldwin on subsequent engines added sides, with sash and glass. The cab

proper, however, was of New England origin, where the severity of the climate demanded it, and where it had been used previous to this period.

Forty-two engines were completed in 1846, and thirty-nine in 1847. The only novelty to be noted among them was the engine "M. G. Bright," built for operating the inclined plane on the Madison and Indianapolis Railroad. The rise of this incline was one in seventeen, from the bank of the Ohio River at Madison. The engine had eight wheels, forty-two inches in diameter, connected, and worked in the usual manner by outside inclined cylinders, fifteen and one-half inches diameter by twenty inches stroke. A second pair of cylinders, seventeen inches in diameter with eighteen inches stroke of piston, was placed vertically over the boiler, midway between the furnace and smoke-arch. The connecting-rods worked by these cylinders connected with cranks on a shaft under the boiler. This shaft carried a single cog-wheel at its centre, and this cog-wheel engaged with another of about twice its diameter on a second shaft adjacent to it and in the same plane. The cog-wheel on this latter shaft worked in a rack-rail placed in the centre of the track. The shaft itself had its bearings in the lower ends of two vertical rods, one on each side of the boiler, and these rods were united over the boiler by a horizontal bar which was connected by means of a bent lever and connecting-rod to the piston worked by a small horizontal cylinder placed on top of the boiler. By means of this cylinder, the yoke carrying the shaft and cog-wheel could be depressed and held down so as to engage the cogs with the rack-rail, or raised out of the way when only the ordinary driving-wheels were required. This device was designed by Mr. Andrew Cathcart, Master Mechanic of the Madison and Indianapolis Railroad. A similar machine, the "John Brough," for the same plane, was built by Mr. Baldwin in 1850. The incline was worked with a rack-rail and these engines until it was finally abandoned and a line with easier gradients substituted.

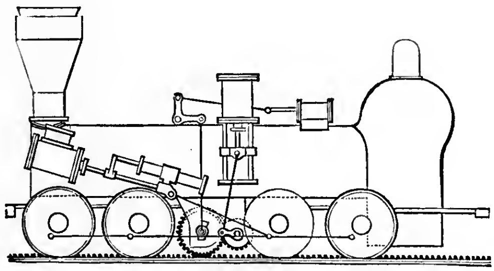


Fig. 11.—Baldwin Engine for Rack-Rail, 1847.

The use of iron tubes in freight engines grew in favor, and in October, 1847, Mr. Baldwin noted that he was fitting his flues with copper ends, "for riveting to the boiler."

The subject of burning coal continued to engage much attention, but the use of anthracite had not as yet been generally successful. In October, 1847, the Baltimore and Ohio Railroad Company advertised for proposals for four engines to burn Cumberland coal, and the order was taken and filled by Mr. Baldwin with four of his eight-wheels-connected machines. These engines had a heater on top of the boiler for heating the feed-water, and a grate with a rocking-bar in the centre, having fingers on each side which interlocked with projections on fixed bars, one in front and one behind. The rocking-bar was operated from the

footboard. This appears to have been the first instance of the use of a rocking-grate in the practice of these works.

The year 1848 showed a falling off in business, and only twenty engines were turned out. In the following year, however, there was a rapid recovery, and the production of the works increased to thirty, followed by thirty-seven in 1850, and fifty in 1851. These engines, with a few exceptions, were confined to three patterns, the eight-wheeled four-coupled engine, from twelve to nineteen tons in weight, for passengers and freight, and the six- and eight-wheels-connected engine, for freight exclusively, the six-wheeled machine weighing from twelve to seventeen tons, and the eight-wheeled from eighteen to twenty-seven tons. The wheels of these six- and eight-wheels-connected machines were made generally forty-two, with occasional variations up to forty-eight, inches in diameter.

The exceptions referred to in the practice of these years were the fast passenger engines built by Mr. Baldwin during this period. Early in 1848 the Vermont Central Railroad was approaching completion, and Governor Paine, the President of the Company, conceived the idea that the passenger service on the road required locomotives capable of running at very high velocities. Mr. Baldwin at once undertook to construct for that Company a locomotive which could run with a passenger train at a speed of sixty miles per hour. The work was begun early in 1848, and in March of that year Mr. Baldwin filed a caveat for his design. The engine was completed in 1849, and was named the "Governor Paine." It had one pair of driving-wheels, six and a half feet in diameter, placed back of the fire-box. Another pair of wheels, but smaller and unconnected, was placed directly in front of the fire-box, and a four-wheeled truck carried the front of the engine. The cylinders were seventeen and a quarter inches diameter and twenty inches stroke, and were placed horizontally between the frames and the boiler, at about the middle of the waist. The connecting-rods took hold of "half-cranks" inside of the driving-wheels. The object of placing the cylinders at the middle of the boiler was to lessen or obivate the lateral motion of the engine, produced when the cylinders were attached to the smoke-arch. The bearings on the two rear axles were so contrived that, by means of a lever, a part of the weight of the engine usually carried on the wheels in front of the fire-box could be transferred to the driving-axle. The "Governor Paine" was used for several years on the Vermont Central Railroad, and then rebuilt into a four-coupled machine. During its career, it was stated by the officers of the road that it could be started from a state of rest and run a mile in forty-three

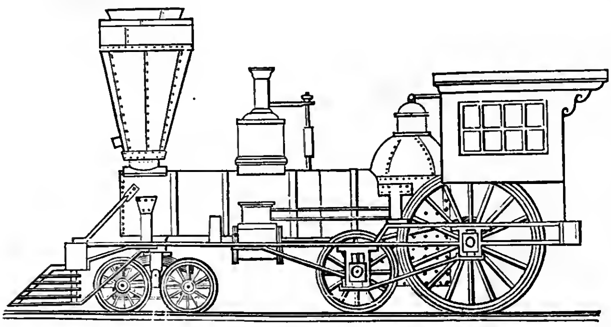


FIG. 12.—BALDWIN FAST PASSENGER ENGINE, 1848.

seconds. Three engines on the same plan, but with cylinders fourteen by twenty, and six-feet driving-wheels, the "Mifflin," "Blair," and "Indiana," were also built for the Pennsylvania Railroad Company in 1849. They weighed each about forty-seven thousand pounds, distributed as follows: eighteen thousand on driving-wheels, fourteen thousand on the pair of wheels in front of the fire-box, and fifteen thousand on the truck. By applying the lever, the weight on the driving-wheels could be increased to about twenty-four thousand pounds, the weight on the wheels in front of the fire-box being correspondingly reduced. A speed of four miles in three minutes is recorded for them, and upon one occasion President Taylor was taken in a special train over the road by one of these machines at a speed of sixty miles an hour. One other engine of this pattern, the "Susquehanna," was built for the Hudson River Railroad Company in 1850. Its cylinders were fifteen inches diameter by twenty inches stroke, and driving-wheels six feet in diameter. All these engines, however, were short-lived, and died young, of insufficient adhesion.

Eight engines with four driving-wheels connected and half-crank axles were built for the New York and Erie Railroad Company in 1849, with seventeen by twenty-inch cylinders; one-half of the number with six-feet and the rest with five-feet driving-wheels. These machines were among the last on which the half-crank axle was used. Thereafter, outside-connected engines were constructed almost exclusively.

In May, 1848, Mr. Baldwin filed a caveat for a four-cylinder locomotive, but never carried the design into execution. The first instance of the use of steel axles in the practice of the establishment occurred during the same year,—a set being placed as an experiment under an engine constructed for the Pennsylvania Railroad Company. In 1850 the old form of dome boiler, which had characterized the Baldwin engine since 1834, was abandoned, and the wagon-top form substituted.

The business in 1851 had reached the full capacity of the shop, and the next year marked the completion of about an equal number of engines (forty-nine). Contracts for work extended a year ahead, and, to meet the demand, the facilities in the various departments were increased, and resulted in the construction of sixty engines in 1853, and sixty-two in 1854.

At the beginning of the latter year, Mr. Matthew Baird, who had been connected with the works since 1836 as one of its foremen, entered into partnership with Mr. Baldwin, and the style of the firm was made M. W. Baldwin & Co.

The only novelty in the general plan of engines during this period was the addition of the ten-wheeled engine to the patterns of the establishment. The success of Mr. Baldwin's engines with all six or eight wheels connected, and the two front pairs combined by the parallel beams into a flexible truck, had been so marked that it was natural that he should oppose any other plan for freight service. The ten-wheeled engine, with six driving-wheels connected, had, however, now become a competitor. This plan of engine was first patented by Septimus Norris, of Philadelphia, in 1846, and the original design was apparently

to produce an engine which should have equal tractive power with the Baldwin six-wheels-connected machine. This the Norris patent sought to accomplish by proposing an engine with six driving-wheels connected, and so disposed as to carry substantially the whole weight, the forward driving-wheels being in advance of the centre of gravity of the engine, and the truck only serving as a guide, the front of the engine being connected with it by a pivot-pin, but without a bearing on the centre-plate. Mr. Norris's first engine on this plan was tried in April, 1847, and was found not to pass curves so readily as was expected. As the truck carried little or no weight, it would not keep the track. The New York and Erie Railroad Company, of which John Brandt was then Master Mechanic, shortly afterwards adopted the ten-wheeled engine, modified in plan so as to carry a part of the weight on the truck. Mr. Baldwin filled an order for this company, in 1850, of four eight-wheels-connected engines, and in making the contract he agreed to substitute a truck for the front pair of wheels if desired after trial. This, however, he was not called upon to do.

In February, 1852, Mr. J. Edgar Thomson, President of the Pennsylvania Railroad Company, invited proposals for a number of freight locomotives of fifty-six thousand pounds weight each. They were to be adapted to burn bituminous coal, and to have six wheels connected and a truck in front, which might be either of two or four wheels. Mr. Baldwin secured the contract, and built twelve engines of the prescribed dimensions, viz., cylinders eighteen by twenty-two; driving-wheels forty-four inches in diameter, with chilled tires. Several of these engines were constructed with a single pair of truck-wheels in front of the driving-wheels, but back of the cylinders. It was found, however, after the engines were put in service, that the two truck-wheels carried eighteen thousand or nineteen thousand pounds, and this was objected to by the company as too great a weight to be carried on a single pair of wheels. On the rest of the engines of the order, therefore, a four-wheeled truck in front was employed.

The ten-wheeled engine thereafter assumed a place in the Baldwin classification. In 1855–56, two of twenty-seven tons weight, nineteen by twenty-two cylinders, forty-eight inches driving-wheels, were built for the Portage Railroad, and three for the Pennsylvania Railroad. In 1855, '56, and '57, fourteen of the same dimensions were built for the Cleveland and Pittsburg Railroad; four for the Pittsburg, Fort Wayne and Chicago Railroad; and one for the Marietta and Cincinnati Railroad. In 1858 and '59, one was constructed for the South Carolina Railroad, of the same size, and six lighter ten-wheelers, with cylinders fifteen and a half by twenty-two, and four-feet driving-wheels, and two with cylinders sixteen by twenty-two, and four-feet driving-wheels, were sent out to railroads in Cuba.

It was some years—not until after 1860, however—before this pattern of engine wholly superseded in Mr. Baldwin's practice the old plan of freight engine on six or eight wheels, all connected.

On three locomotives—the "Clinton," "Athens," and "Sparta"—completed for the Central Railroad of Georgia in July, 1852, the driving-boxes were made with

a slot or cavity in the line of the vertical bearing on the journal. The object was to produce a more uniform distribution of the wear over the entire surface of the bearing. This was the first instance in which this device, which has since come into general use, was employed in the Works, and the boxes were so made by direction of Mr. Charles Whiting, then Master Mechanic of the Central Railroad of Georgia. He subsequently informed Mr. Baldwin that this method of fitting up driving-boxes had been in use on the road for several years previous to his connection with the company. As this device was subsequently made the subject of a patent by Mr. David Matthew, these facts may not be without interest.

In 1853, Mr. Charles Ellet, Chief Engineer of the Virginia Central Railroad, laid a temporary track across the Blue Ridge, at Rock Fish Gap, for use during the construction of a tunnel through the mountain. This track was twelve thousand five hundred feet in length on the eastern slope, ascending in that distance six hundred and ten feet, or at the average rate of one in twenty and a half feet. The maximum grade was calculated for two hundred and ninety-six feet per mile, and prevailed for half a mile. It was found, however, in fact, that the grade in places exceeded three hundred feet per mile. The shortest radius of curvature was two hundred and thirty-eight feet. On the western slope, which was ten thousand six hundred and fifty feet in length, the maximum grade was two hundred and eighty feet per mile, and the ruling radius of curvature three hundred feet. This track was worked by two of the Baldwin six-wheels-connected flexible-beam truck locomotives constructed in 1853–54. From a description of this track, and the mode of working it, published by Mr. Ellet in 1856, the following is extracted:

"The locomotives mainly relied on for this severe duty were designed and constructed by the firm of M. W. Baldwin & Company, of Philadelphia. The slight modifications introduced at the instance of the writer to adapt them better to the particular service to be performed in crossing the Blue Ridge, did not touch the working proportions or principle of the engines, the merits of which are due to the patentee, M. W. Baldwin, Esq.

"These engines are mounted on six wheels, all of which are drivers, and coupled, and forty-two inches diameter. The wheels are set very close, so that the distance between the extreme points of contact of the wheels and the rail, of the front and rear drivers, is nine feet four inches. This closeness of the wheels, of course, greatly reduces the difficulty of turning the short curves of the road. The diameter of the cylinders is sixteen and a half inches, and the length of the stroke twenty inches. To increase the adhesion, and at the same time avoid the resistance of a tender, the engine carries its tank upon the boiler, and the footboard is lengthened out and provided with suspended side-boxes, where a supply of fuel may be stored. By this means the weight of wood and water, instead of abstracting from the effective power of the engine, contributes to its adhesion and consequent ability to climb the mountain. The total weight of these engines is fifty-five thousand pounds, or twenty-seven and a half tons, when the boiler and tank are supplied with water, and fuel enough for a trip of eight miles is on board. The capacity of the tank is sufficient to hold one hundred cubic feet of water, and it has storage-room on top for one hundred cubic feet of wood, in addition to what may be carried in the side-boxes and on the footboard.

"To enable the engines better to adapt themselves to the flexures of the road, the front and

middle pairs of drivers are held in position by wrought-iron beams, having cylindrical boxes in each end for the journal-bearings, which beams vibrate on spherical pins fixed in the frame of the engine on each side, and resting on the centres of the beams. The object of this arrangement is to form a truck, somewhat flexible, which enables the drivers more readily to traverse the curves of the road.

"The writer has never permitted the power of the engines on this mountain road to be fully tested. The object has been to work the line regularly, economically, and, above all, *safely;* and these conditions are incompatible with experimental loads subjecting the machinery to severe strains. The regular daily service of each of the engines is to make four trips, of eight miles, over the mountain, drawing one eight-wheel baggage car, together with two eight-wheel passenger cars, in each direction.

"In conveying freight, the regular train on the mountain is three of the eight-wheel house-cars, fully loaded, or four of them when empty or partly loaded.

"These three cars, when full, weigh, with their loads, from forty to forty-three tons. Sometimes, though rarely, when the business has been unusually heavy, the loads have exceeded fifty tons.

"With such trains the engines are stopped on the track, ascending or descending, and are started again, on the steepest grades, at the discretion of the engineer.

"Water, for the supply of the engines, has been found difficult to obtain on the mountain; and, since the road was constructed, a tank has been established on the eastern slope, where the ascending engines stop daily on a grade of two hundred and eighty feet per mile, and are there held by the brakes while the tank is being filled, and started again at the signal and without any difficulty.

"The ordinary speed of the engines, when loaded, is seven and a half miles an hour on the ascending grades, and from five and a half to six miles an hour on the descent.

"When the road was first opened, it speedily appeared that the difference of forty-three feet on the western side, and fifty-eight feet on the eastern side, between the grades on curves of three hundred feet radii and those on straight lines, was not sufficient to compensate for the increased friction due to such curvature. The velocity, with a constant supply of steam, was promptly retarded on passing from a straight line to a curve, and promptly accelerated again on passing from the curve to the straight line. But, after a little experience in the working of the road, it was found advisable to supply a small amount of grease to the flange of the engine by means of a sponge, saturated with oil, which, when needed, is kept in contact with the wheel by a spring. Since the use of the oil was introduced, the difficulty of turning the curves has been so far diminished, that it is no longer possible to determine whether grades of two hundred and thirty-seven and six-tenths feet per mile on curves of three hundred feet radius, or grades of two hundred and ninety-six feet per mile on straight lines, are traversed most rapidly by the engine.

"When the track is in good condition, the brakes of only two of the cars possess sufficient power to control and regulate the movement of the train,—that is to say, they will hold back the two cars and the engine. When there are three or more cars in the train, the brakes on the cars, of course, command the train so much the more easily.

"But the safety of the train is not dependent on the brakes of the car. There is also a valve or air-cock in the steam-chest, under the control of the engineer. This air-cock forms an independent brake, exclusively at the command of the engineer, and which can always be applied when the engine itself is in working order. The action of this power may be made ever so gradual, either slightly relieving the duty of the brakes on the cars, or bringing into play the entire power of the engine. The train is thus held in complete command."

The Mountain Top Track, it may be added, was worked successfully for several years, by the engines described in the above extract, until it was abandoned on the completion of the tunnel. The exceptionally steep grades and short curves

which characterized the line, afforded a complete and satisfactory test of the adaptation of these machines to such peculiar service.

But the period now under consideration was marked by another, and a most important, step in the progress of American locomotive practice. We refer to the introduction of the link-motion. Although this device was first employed by William T. James, of New York, in 1832, and eleven years later by the Stephensons, in England, and was by them applied thenceforward on their engines, it was not until 1849 that it was adopted in this country. In that year Mr. Thomas Rogers, of the Rogers Locomotive and Machine Company, introduced it in his practice. Other builders, however, strenuously resisted the innovation, and none more so than Mr. Baldwin. The theoretical objections which confessedly apply to the device, but which practically have been proved to be unimportant, were urged from the first by Mr. Baldwin as arguments against its use. The strong claim of the advocates of the link-motion, that it gave a means of cutting off steam at any point of the stroke, could not be gainsaid, and this was admitted to be a consideration of the first importance. This very circumstance undoubtedly turned Mr. Baldwin's attention to the subject of methods for cutting off steam, and one of the first results was his "Variable Cut-off," patented April 27, 1852. This device consisted of two valves, the upper sliding upon the lower, and worked by an eccentric and rock-shaft in the usual manner. The lower valve fitted steam-tight to the sides of the steam-chest and the under surface of the upper valve. When the piston reached each end of its stroke, the full pressure of steam from the boiler was admitted around the upper valve, and transferred the lower valve instantaneously from one end of the steam-chest to the other. The openings through the two valves were so arranged that steam was admitted to the cylinder only for a part of the stroke. The effect was, therefore, to cut off steam at a given point, and to open the induction and exhaust ports substantially at the same instant and to their full extent. The exhaust port, in addition, remained fully open while the induction port was gradually closing, and after it had entirely closed. Although this device was never put in use, it may be noted in passing that it contained substantially the principle of the steam-pump, as since patented and constructed.

Early in 1853, Mr. Baldwin abandoned the half-stroke cut-off, previously described, and which he had been using since 1845, and adopted the variable cut-off, which was already employed by other builders. One of his letters, written in January, 1853, states his position, as follows:

> "I shall put on an improvement in the shape of a variable cut-off, which can be operated by the engineer while the machine is running, and which will cut off anywhere from six to twelve inches, according to the load and amount of steam wanted, and this without the link-motion, which I could never be entirely satisfied with. I still have the independent cut-off, and the additional machinery to make it variable will be simple and not liable to be deranged."

This form of cut-off was a separate valve, sliding on a partition plate between it and the main steam-valve, and worked by an independent eccentric and rock-

shaft. The upper arm of the rock-shaft was curved so as to form a radius-arm, on which a sliding-block, forming the termination of the upper valve-rod, could be adjusted and held at varying distances from the axis, thus producing a variable travel of the upper valve. This device did not give an absolutely perfect cut-off, as it was not operative in backward gear, but when running forward it would cut off with great accuracy at any point of the stroke, was quick in its movement, and economical in the consumption of fuel.

After a short experience with this arrangement of the cut-off, the partition plate was omitted, and the upper valve was made to slide directly on the lower. This was eventually found objectionable, however, as the lower valve would soon cut a hollow in the valve-face. Several unsuccessful attempts were made to remedy this defect by making the lower valve of brass, with long bearings, and making the valve-face of the cylinder of hardened steel; finally, however, the plan of one valve on the other was abandoned and a recourse was again had to an interposed partition plate, as in the original half-stroke cut-off.

Mr. Baldwin did not adopt this form of cut-off without some modification of his own, and the modification in this instance consisted of a peculiar device, patented September 13, 1853, for raising and lowering the block on the radius-arm. A quadrant was placed

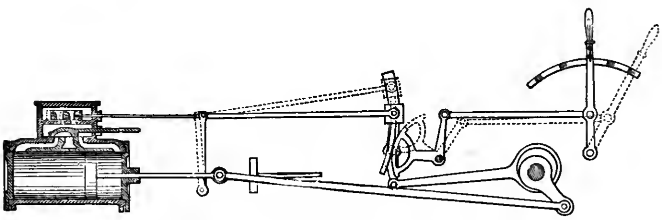


FIG. 13.—VARIABLE CUT-OFF ADJUSTMENT.

so that its circumference bore nearly against a curved arm projecting down from the sliding-block, and which curved in the reverse direction from the quadrant. Two steel straps side by side were interposed between the quadrant and this curved arm. One of the straps was connected to the lower end of the quadrant and the upper end of the curved arm; the other, to the upper end of the quadrant and the lower end of the curved arm. The effect was the same as if the quadrant and arm geared into each other in any position by teeth, and theoretically the block was kept steady in whatever position placed on the radius-arm of the rock-shaft. This was the object sought to be accomplished, and was stated in the specification of the patent as follows:

"The principle of varying the cut-off by means of a vibrating arm and sliding pivot-block has long been known, but the contrivances for changing the position of the block upon the arm have been very defective. The radius of motion of the link by which the sliding-block is changed on the arm, and the radius of motion of that part of the vibrating arm on which the block is placed, have, in this kind of valve gear, as heretofore constructed, been different, which produced a continual rubbing of the sliding-block upon the arm while the arm is vibrating; and as the block for the greater part of the time occupies one position on the arm, and only has to be moved toward either extremity occasionally, that part of the arm on which the block is most used soon becomes so worn that the block is loose, and jars."

This method of varying the cut-off was first applied on the engine "Belle," delivered to the Pennsylvania Railroad Company, December 6, 1854, and thereafter was for some time employed by Mr. Baldwin. It was found, however, in practice that the steel straps would stretch sufficiently to allow them to buckle and break, and hence they were soon abandoned, and chains substituted between the quadrant and curved arm of the sliding-block These chains in turn proved little better, as they lengthened, allowing lost motion, or broke altogether, so that eventually the quadrant was wholly abandoned, and recourse was finally had to the lever and link for raising and lowering the sliding-block. As thus arranged, the cut-off was substantially what was known as the "Cuyahoga Cut-off," as introduced by Mr. Ethan Rogers, of the Cuyahoga Works, Cleveland, Ohio, except that Mr. Baldwin used a partition plate between the upper and the lower valve.

But while Mr. Baldwin, in common with many other builders, was thus resolutely opposing the link-motion, it was nevertheless rapidly gaining favor with railroad managers. Engineers and master mechanics were everywhere learning to admire its simplicity, and were manifesting an enthusiastic preference for engines so constructed. At length, therefore, he was forced to succumb; and the link was applied to the "Pennsylvania," one of two engines completed for the Central Railroad of Georgia, in February, 1854. The other engine of the order, the "New Hampshire," had the variable cut-off, and Mr. Baldwin, while yielding to the demand in the former engine, was undoubtedly sanguine that the working of the latter would demonstrate the inferiority of the new device. In this, however, he was disappointed, for in the following year the same company ordered three more engines, on which they specified the link-motion. In 1856 seventeen engines for nine different companies had this form of valve gear, and its use was thus incorporated in his practice. It was not, however, until 1857 that he was induced to adopt it exclusively.

February 14, 1854, Mr. Baldwin and Mr. David Clark, Master Mechanic of the Mine Hill Railroad, took out conjointly a patent for a feed-water heater, placed at the base of a locomotive chimney, and consisting of one large vertical flue, surrounded by a number of smaller ones. The exhaust steam was discharged from the nozzles through the large central flue, creating a draft of the products of combustion through the smaller surrounding flues. The pumps forced the feed-water into the chamber around these flues, whence it passed to the boiler by a pipe from the back of the stack. This heater was applied on several engines for the Mine Hill Railroad, and on a few for other roads; but its use was exceptional, and lasted only for a year or two.

In December of the same year, Mr. Baldwin filed a caveat for a variable exhaust, operated automatically, by the pressure of steam, so as to close when the pressure was lowest in the boiler, and open with the increase of pressure. The device was never put in service.

The use of coal, both bituminous and anthracite, as a fuel for locomotives, had by this time become a practical success. The economical combustion of

bituminous coal, however, engaged considerable attention. It was felt that much remained to be accomplished in consuming the smoke and deriving the maximum of useful effect from the fuel. Mr. Baird, who was now associated with Mr. Baldwin in the management of the business, made this matter a subject of careful study and investigation. An experiment was conducted under his direction, by placing a sheet-iron deflector in the fire-box of an engine on the Germantown and Norristown Railroad. The success of the trial was such as to show conclusively that a more complete combustion resulted. As, however, a deflector formed by a single plate of iron would soon be destroyed by the action of the fire, Mr. Baird proposed to use a water-leg projecting upward and backward from the front of the fire-box under the flues. Drawings and a model of the device were prepared, with a view of patenting it, but subsequently the intention was abandoned, Mr. Baird concluding that a fire-brick arch as a deflector to accomplish the same object was preferable. This was accordingly tried on two locomotives built for the Pennsylvania Railroad Company in 1854, and was found so valuable an appliance that its use was at once established, and it was put on a number of engines built for railroads in Cuba and elsewhere. For several years the fire-bricks were supported on side plugs; but in 1858, in the "Media," built for the West Chester and Philadelphia Railroad Company, water-pipes extending from the crown obliquely downward and curving to the sides of the fire-box at the bottom were successfully used for the purpose.

The adoption of the link-motion may be regarded as the dividing line between the present and the early and transitional stage of locomotive practice. Changes since that event have been principally in matters of detail, but it is the gradual perfection of these details which has made the locomotive the symmetrical, efficient, and wonderfully complete piece of mechanism it is to-day. In perfecting these minutiæ, the Baldwin Locomotive Works has borne its part, and it only remains to state briefly its contributions in this direction.

The production of the establishment during the six years from 1855 to 1860, inclusive, was as follows: forty-seven engines in 1855; fifty-nine in 1856; sixty-six in 1857; thirty-three in 1858; seventy in 1859; and eighty-three in 1860. The greater number of these were of the ordinary type, four wheels coupled, and a four-wheeled truck, and varying in weight from fifteen ton engines, with cylinders twelve by twenty-two, to twenty-seven ton engines, with cylinders sixteen by twenty-four. A few ten-wheeled engines were built, as has been previously noted, and the remainder were the Baldwin flexible-truck six- and eight-wheels-connected engines. The demand for these, however, was now rapidly falling off, the ten-wheeled and heavy "C" engines taking their place, and by 1859 they ceased to be built, save in exceptional cases, as for some foreign roads, from which orders for this pattern were still occasionally received.

A few novelties characterizing the engines of this period may be mentioned. Several engines built in 1855 had cross-flues placed in the fire-box, under the crown, in order to increase the heating surface. This feature, however, was found impracticable, and was soon abandoned. The intense heat to which the

flues were exposed converted the water contained in them into highly superheated steam, which would force its way out through the water around the fire-box with violent ebullitions. Four engines were built for the Pennsylvania Railroad Company, in 1856–57, with straight boilers and two domes. The "Delano" grate, by means of which the coal was forced into the fire-box from below, was applied on four ten-wheeled engines for the Cleveland and Pittsburg Railroad in 1857. In 1859 several engines were built with the form of boiler introduced on the Cumberland Valley Railroad in 1851 by Mr. A. F. Smith, and which consisted of a combustion-chamber in the waist of the boiler, next the fire-box. This form of boiler was for some years thereafter largely used in engines for soft coal. It was at first constructed with the "water-leg," which was a vertical water-space, connecting the top and bottom sheets of the combustion-chamber, but eventually this feature was omitted, and an unobstructed combustion-chamber employed. Several engines were built for the Philadelphia, Wilmington and Baltimore Railroad Company in 1859, and thereafter, with the "Dimpfel" boiler, in which the tubes contain water, and, starting downward from the crown-sheet, are curved to the horizontal, and terminate in a narrow water-space next the smoke-box. The whole waist of the boiler, therefore, forms a combustion-chamber, and the heat and gases, after passing for their whole length along and around the tubes, emerge into the lower part of the smoke-box.

In 1860 an engine was built for the Mine Hill Railroad, with a boiler of a peculiar form. The top sheets sloped upward from both ends toward the centre, thus making a raised part or hump in the centre. The engine was designed to work on heavy grades, and the object sought by Mr. Wilder, the Superintendent of the Mine Hill Railroad, was to have the water always at the same height in the space from which steam was drawn, whether going up or down grade.

All these experiments are indicative of the interest then prevailing upon the subject of coal-burning. The result of experience and study had meantime satisfied Mr. Baldwin that to burn soft coal successfully required no peculiar devices; that the ordinary form of boiler, with plain fire-box, was right, with perhaps the addition of a fire-brick deflector; and that the secret of the economical and successful use of coal was in the mode of firing, rather than in a different form of furnace.

The year 1861 witnessed a marked falling off in the production. The breaking out of the civil war at first unsettled business, and by many it was thought that railroad traffic would be so largely reduced that the demand for locomotives must cease altogether. A large number of hands were discharged from the works, and only forty locomotives were turned out during the year. It was even seriously contemplated to turn the resources of the establishment to the manufacture of shot and shell, and other munitions of war, the belief being entertained that the building of locomotives would have to be altogether suspended. So far, however, was this from being the case, that, after the first

excitement had subsided, it was found that the demand for transportation by the general government, and by the branches of trade and production stimulated by the war, was likely to tax the carrying capacity of the principal Northern railroads to the fullest extent. The government itself became a large purchaser of locomotives, and it is noticeable, as indicating the increase of travel and freight transportation, that heavier machines than had ever before been built became the rule. Seventy-five engines were sent from the works in 1862; ninety-six in 1863; one hundred and thirty in 1864; and one hundred and fifteen in 1865. During two years of this period, from May, 1862, to June, 1864, thirty-three engines were built for the United States Military Railroads. The demand from the various coal-carrying roads in Pennsylvania and vicinity was particularly active, and large numbers of ten-wheeled engines, and of the heaviest eight-wheeled four-coupled engines, were built. Of the latter class, the majority were with fifteen- and sixteen-inch cylinders, and of the former, seventeen- and eighteen-inch cylinders.

The introduction of several important features in construction marks this period. Early in 1861, four eighteen-inch cylinder freight locomotives, with six coupled wheels, fifty-two inches in diameter, and a Bissell pony-truck with radius-bar in front, were sent to the Louisville and Nashville Railroad Company. This was the first instance of the use of the Bissell truck in the Baldwin Works. These engines, however, were not of the regular "Mogul" type, as they were only modifications of the ten-wheeler, the drivers retaining the same position, well back, and a pair of pony-wheels on the Bissell plan taking the place of the ordinary four-wheeled truck. Other engines of the same pattern, but with eighteen and one-half inch cylinders, were built in 1862–63, for the same company, and for the Dom Pedro II. Railway of Brazil.

The introduction of steel in locomotive-construction was a distinguishing feature of the period. Steel tires were first used in the works in 1862, on some engines for the Dom Pedro II. Railway of South America. Their general adoption on American Railroads followed slowly. No tires of this material were then made in this country, and it was objected to their use that, as it took from sixty to ninety days to import them, an engine, in case of a breakage of one of its tires, might be laid up useless for several months. To obviate this objection M. W. Baldwin & Co. imported five hundred steel tires, most of which were kept in stock, from which to fill orders. The steel tires as first used in 1862 on the locomotives for the Dom Pedro Segundo Railway were made with a "shoulder" at one edge of the internal periphery, and were shrunk on the wheel-centres. The sketch on opposite page (Figure 14) shows a section of the tire as then used.

Steel fire-boxes were first built for some engines for the Pennsylvania Railroad Company in 1861. English steel of a high temper was used, and at the first attempt the fire-boxes cracked in fitting them in the boilers, and it became necessary to take them out and substitute copper. American homogeneous cast-steel was then tried on engines 231 and 232, completed for the Pennsylvania

Railroad in January, 1862, and it was found to work successfully. The fire-boxes of nearly all engines thereafter built for that road were of this material, and in 1866 its use for the purpose became general. It may be added that while all steel sheets for fire-boxes or boilers are required to be thoroughly annealed before delivery, those which are flanged or worked in the process of boiler construction are a second time annealed before riveting.

Another feature of construction gradually adopted was the placing of the cylinders horizontally. This was first done in the case of an outside-connected engine, the "Ocmulgee," which was sent to the South-western Railroad Company of Georgia, in January, 1858. This engine had a square smoke-box, and the cylinders were bolted horizontally to its sides. The plan of casting the cylinder and half-saddle in one piece and fitting it to the round smoke-box was introduced by Mr. Baldwin, and grew naturally out of his original method of construction. Mr. Baldwin was the first American builder to use an outside cylinder, and he made it for his early engines with a circular flange cast to it, by which it could be bolted to the boiler. The cylinders were gradually brought lower, and at a less angle, and the flanges prolonged and enlarged. In 1852, three six-wheels-connected engines, for the Mine Hill Railroad Company, were built with the cylinder flanges brought around under the smoke-box until they nearly met, the space between them being filled with a spark-box. This was practically equivalent to making the cylinder and half-saddle in one casting. Subsequently, on other engines on which the spark-box was not used, the half-saddles were cast so as almost to meet under the smoke-box, and, after the cylinders were adjusted in position, wedges were fitted in the interstices and the saddles bolted together. It was finally discovered that the faces of the two half-saddles might be planed and finished so that they could be bolted together and bring the cylinders accurately in position, thus avoiding the troublesome and tedious job of adjusting them by chipping and fitting to the boiler and frames. With this method of construction, the cylinders were placed at a less and less angle, until at length the truck-wheels were spread sufficiently, on all new or modified classes of locomotives in the Baldwin list, to admit of the cylinders being hung horizontally, as is the present almost universal American practice. By the year 1865 horizontal cylinders were made in all cases where the patterns would allow it. The advantages of this arrangement are manifestly in the interest of simplicity and economy, as the cylinders are thus rights or lefts, indiscriminately, and a single pattern answers for either side.

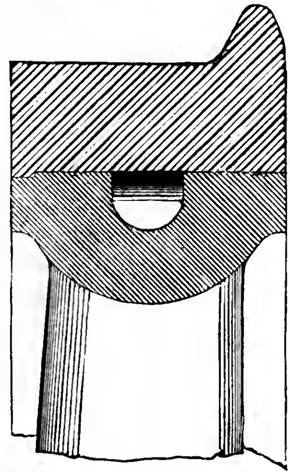


Fig. 14.

A distinguishing feature in the method of construction which characterizes these works is the extensive use of a system of standard gauges and templets, to which all work admitting of this process is required to be made. The im-

portance of this arrangement, in securing absolute uniformity of essential parts in all engines of the same class, is manifest, and with the increased production since 1861 it became a necessity as well as a decided advantage. It has already been noted that as early as 1839 Mr. Baldwin felt the importance of making all like parts of similar engines absolutely uniform and interchangeable. It was not attempted to accomplish this object, however, by means of a complete system of standard gauges, until many years later. In 1861 a beginning was made of organizing all the departments of manufacture upon this basis, and from it has since grown an elaborate and perfected system, embracing all the essential details of construction. An independent department of the works, having a separate foreman and an adequate force of skilled workmen, with special tools adapted to the purpose, is organized as the Department of Standard Gauges. A system of standard gauges and templets for every description of work to be done is made and kept by this department. The original templets are kept as "standards," and are never used on the work itself, but from them exact duplicates are made, which are issued to the foremen of the various departments, and to which all work is required to conform. The working gauges are compared with the standards at regular intervals, and absolute uniformity is thus maintained. The system is carried into every possible important detail. Frames are planed and slotted to gauges, and drilled to steel bushed templets. Cylinders are bored and planed, and steam-ports, with valves and steam-chests, finished and fitted, to gauges. Tires are bored, centres turned, axles finished, and cross-heads, guides, guide-bearers, pistons, connecting- and parallel-rods planed, slotted, or finished by the same method. Every bolt about the engine is made to a gauge, and every hole drilled and reamed to a templet. The result of the system is an absolute uniformity and interchangeableness of parts in engines of the same class, insuring to the purchaser the minimum cost of repairs, and rendering possible, by the application of this method, the large production which these works have accomplished.

Thus had been developed and perfected the various essential details of existing locomotive practice when Mr. Baldwin died, September 7, 1866. He had been permitted, in a life of unusual activity and energy, to witness the rise and wonderful increase of a material interest which had become the distinguishing feature of the century. He had done much, by his own mechanical skill and inventive genius, to contribute to the development of that interest. His name was as "familiar as household words" wherever on the American continent the locomotive had penetrated. An ordinary ambition might well have been satisfied with this achievement. But Mr. Baldwin's claim to the remembrance of his fellowmen rests not alone on the results of his mechanical labors. A merely technical history, such as this, is not the place to do justice to his memory as a man, as a Christian, and as a philanthropist; yet the record would be manifestly imperfect, and would fail properly to reflect the sentiments of his business associates who so long knew him in all relations of life, were no reference made to his many virtues and noble traits of character. Mr. Baldwin was a man of sterling

integrity and singular conscientiousness. To do right, absolutely and unreservedly, in all his relations with men, was an instinctive rule of his nature. His heroic struggle to meet every dollar of his liabilities, principal and interest, after his failure, consequent upon the general financial crash in 1837, constitutes a chapter of personal self-denial and determined effort which is seldom paralleled in the annals of commercial experience. When most men would have felt that an equitable compromise with creditors was all that could be demanded in view of the general financial embarrassment, Mr. Baldwin insisted upon paying all claims in full, and succeeded in doing so only after nearly five years of unremitting industry, close economy, and absolute personal sacrifices. As a philanthropist and a sincere and earnest Christian, zealous in every good work, his memory is cherished by many to whom his contributions to locomotive improvement are comparatively unknown. From the earliest years of his business life the practice of systematic benevolence was made a duty and a pleasure. His liberality constantly increased with his means. Indeed, he would unhesitatingly give his notes, in large sums, for charitable purposes when money was absolutely wanted to carry on his business. Apart from the thousands which he expended in private charities, and of which, of course, little can be known, Philadelphia contains many monuments of his munificence. Early taking a deep interest in all Christian effort, his contributions to missionary enterprise and church extension were on the grandest scale, and grew with increasing wealth. Numerous church edifices in this city, of the denomination to which he belonged, owe their existence largely to his liberality, and two at least were projected and built by him entirely at his own cost. In his mental character, Mr. Baldwin was a man of remarkable firmness of purpose. This trait was strongly shown during his mechanical career in the persistency with which he would work at a new improvement or resist an innovation. If he was led sometimes to assume an attitude of antagonism to features of locomotive-construction which after-experience showed to be valuable,—and a desire for historical accuracy has required the mention, in previous pages, of several instances of this kind,—it is at least certain that his opposition was based upon a conscientious belief in the mechanical impolicy of the proposed changes.

After the death of Mr. Baldwin the business was reorganized, in 1867, under the title of "The Baldwin Locomotive Works," M. Baird & Co., Proprietors. Messrs. George Burnham and Charles T. Parry, who had been connected with the establishment from an early period, the former in charge of the finances, and the latter as General Superintendent, were associated with Mr. Baird in the copartnership. Three years later, Messrs. Edward H. Williams, William P. Henszey, and Edward Longstreth became members of the firm. Mr. Williams had been connected with railway management on various lines since 1850. Mr. Henszey had been Mechanical Engineer, and Mr. Longstreth the General Superintendent of the works for several years previously.

The production of the Baldwin Locomotive Works from 1866 to 1871, both years inclusive, was as follows:

1866, one hundred and eighteen locomotives.
1867, one hundred and twenty-seven "
1868, one hundred and twenty-four "
1869, two hundred and thirty-five "
1870, two hundred and eighty "
1871, three hundred and thirty-one "

In July, 1866, the engine "Consolidation" was built for the Lehigh Valley Railroad, on the plan and specification furnished by Mr. Alexander Mitchell, Master Mechanic of the Mahanoy Division of that railroad. This engine was intended for working the Mahanoy plane, which rises at the rate of one hundred and thirty-three feet per mile. The "Consolidation" had cylinders twenty by twenty-four, four pairs of wheels connected, forty-eight inches in diameter, and a Bissell pony-truck in front, equalized with the front driving-wheels. The weight of the engine, in working order, was ninety thousand pounds, of which all but about ten thousand pounds was on the driving-wheels. This engine has constituted the first of a class to which it has given its name, and "Consolidation" engines have since been constructed for a large number of railways, not only in the United States, but in Mexico, Brazil, and Australia. Later engines of the class for the four feet eight and a half inch gauge have, however, been made heavier, as will be seen by reference to the description of this type in the Catalogue.

A class of engines known as "Moguls," with three pairs of wheels connected and a swinging pony-truck in front equalized with the forward driving-wheels, took its rise in the practice of this establishment from the "E. A. Douglas," built for the Thomas Iron Company, in 1867. These engines are fully illustrated in the Catalogue. Several sizes of "Moguls" have been built, but principally with cylinders sixteen to nineteen inches in diameter, and twenty-two or twenty-four inches stroke, and with driving-wheels from forty-four to fifty-seven inches in diameter. This plan of engine has rapidly grown in favor for freight service on heavy grades or where maximum loads are to be moved, and has been adopted by several leading lines. Utilizing, as it does, nearly the entire weight of the engine for adhesion, the main and back pairs of driving-wheels being equalized together, as also the front driving-wheels and the pony-wheels, and the construction of the engine with swing-truck and one pair of driving-wheels without flanges allowing it to pass short curves without difficulty, the "Mogul" is generally accepted as a type of engine especially adapted to the economical working of heavy freight traffic.

In 1867, on a number of eight-wheeled four-coupled engines for the Pennsylvania Railroad, the four-wheeled swing-bolster-truck was first applied, and thereafter a large number of engines have been so constructed. The two-wheeled or "pony-truck" has been built both on the Bissell plan, with double inclined slides, and with the ordinary swing-bolster, and in both cases with the radius-bar pivoting from a point about four feet back from the centre of the truck. The four-wheeled truck has been made with swinging or sliding bolster, and both with and without the radius-bar. Of the engines above referred to as the first on which the swing-bolster-truck was applied, four were for express passenger service, with driving-wheels

sixty-seven inches in diameter, and cylinders seventeen by twenty-four. One of them, placed on the road September 9, 1867, was in constant service until May 14, 1871, without ever being off its wheels for repairs, making a total mileage of one hundred and fifty-three thousand two hundred and eighty miles. All of these engines have their driving-wheels spread eight and one-half feet between centres.

Steel flues were first used in three ten-wheeled freight engines, Numbers 211, 338, and 368, completed for the Pennsylvania Railroad in August, 1868. Flues of the same material have also been used in a number of engines for South American railroads. Experience with tubes of this metal, however, has not yet been sufficiently extended to show whether they give any advantages commensurate with their increased cost over iron.

Steel boilers were first made in 1868 for locomotives for the Pennsylvania Railroad Company, and the use of this material for the barrels of boilers as well as for the fire-boxes has continued to some extent. Steel plates somewhat thinner than if of iron have been generally used, but at the same time giving an equal or greater tensile strength. The thoroughly homogeneous character of the steel boiler-plate made in this country recommends it strongly for the purpose.

In 1854 four engines for the Pennsylvania Railroad Company, the "Tiger," "Leopard," "Hornet," and "Wasp," were built with straight boilers and two domes each, and in 1866 this method of construction was revived. Since that date the practice of the establishment has included both the wagon-top boiler with single dome, and the straight boiler with one or two domes. When the straight boiler is used the waist is made about two inches larger in diameter than that of the wagon-top form. About equal space for water and steam is thus given in either case, and, as the number of flues is the same in both forms, more room for the circulation of water between the flues is afforded in the straight boiler, on account of its larger diameter, than in the wagon-top shape. Where the straight boiler is used with two domes the throttle-valve is placed in the forward dome.

In 1868, a locomotive of three and a half feet gauge was constructed for the Averill Coal and Oil Company, of West Virginia. This was the first narrow-gauge locomotive in the practice of the works.

In 1869 three locomotives of the same gauge were constructed for the União Valenciana Railway of Brazil, and were the first narrow-gauge locomotives constructed at these works for general passenger and freight traffic. In the following year the Denver and Rio Grande Railway, of Colorado, was projected on the three-feet gauge, and the first locomotives for the line were designed and built in 1871. Two classes, for passenger and freight respectively, were constructed. The former were six-wheeled, four wheels coupled forty inches in diameter, nine by sixteen cylinders, and weighed each, loaded, about twenty-five thousand pounds. The latter were eight-wheeled, six wheels coupled thirty-six inches in diameter, eleven by sixteen cylinders, and weighed each, loaded, about thirty-five thousand pounds. Each had a swinging-truck of a single pair of wheels in front of the

cylinders. The latter type has been maintained for freight service on most narrow-gauge lines, but principally of larger sizes, engines as heavy as fifty thousand pounds having been turned out. The former type for passenger service was found to be too small and to be unsteady on the track, owing to its comparatively short wheel-base. It was therefore abandoned, and the ordinary "American" pattern, eight-wheeled, four-coupled, substituted. Following the engines for the Denver and Rio Grande Railway, others for other narrow-gauge lines were called for, and the manufacture of this description of rolling stock soon assumed importance. From 1868 to 1870, inclusive, eleven narrow-gauge locomotives were included in the product. The number of narrow-gauge locomotives built in succeeding years has been as follows: 1871, thirty-two; 1872, nineteen; 1873, twenty-nine; 1874, forty-four; 1875, thirty-six; 1876, fifty-one; 1877, sixty-five; 1878, seventy-five; 1879 (in part), seventy-eight.

The "Consolidation" type, as first introduced for the four feet eight and one-half inches gauge in 1866, was adapted to the three-feet gauge in 1873. In 1877 a locomotive on this plan, weighing in working order about sixty thousand pounds, with cylinders fifteen by twenty, was built for working the Garland extension of the Denver and Rio Grande Railway, which crosses the Rocky Mountains with maximum grades of two hundred and eleven feet per mile, and minimum curves of thirty degrees. The performance of this locomotive, the "Alamosa," is given in the following extract from a letter from the then General Superintendent of that railway:

"DENVER, COL., Aug. 31, 1877.

"On the 29th inst. I telegraphed you from Veta Pass—Sangre de Cristo Mountains—that engine 'Alamosa' had just hauled from Garland to the Summit one baggage car and seven coaches, containing one hundred and sixty passengers. Yesterday I received your reply asking for particulars, etc.

"My estimate of the weight was eighty-five net tons, stretched over a distance of three hundred and sixty feet, or including the engine, of four hundred and five feet.

"The occasion of this sized train was an excursion from Denver to Garland and return. The night before, in going over from La Veta, we had over two hundred passengers, but it was 8 P.M., and, fearing a slippery rail, I put on engine No. 19 as a pusher, although the engineer of the 'Alamosa' said he could haul the train, and I believe he could have done so. The engine and train took up a few feet more than the half circle at 'Mule Shore,' where the radius is one hundred and ninety-three feet. The engine worked splendidly, and moved up the two hundred and eleven feet grades and around the thirty degree curves seemingly with as much ease as our passenger engines on 75 feet grades with three coaches and baggage cars.

"The 'Alamosa' hauls regularly eight loaded cars and caboose, about one hundred net tons; length of train about two hundred and thirty feet.

"The distance from Garland to Veta Pass is fourteen and one-quarter miles, and the time is one hour and twenty minutes.

Respectfully yours,

(Signed) "W. W. BORST, *Sup't.*"

In addition to narrow-gauge locomotives for the United States, this branch of the product has included a large number of one-metre gauge locomotives for Brazil, three-feet gauge locomotives for Cuba, Mexico, and Peru, and three and one-half feet gauge stock for Costa Rica, Nicaragua, Canada, and Australia.

Locomotives for single-rail railroads were built in 1878 and early in 1879, adapted respectively to the systems of General Roy Stone and Mr. W. W. Riley.

Mine locomotives, generally of narrow gauge, for underground work, and not over five and one-half feet in height, were first built in 1870. These machines have generally been four-wheels-connected, with inside cylinders and a crank-axle. The width over all of this plan is only sixteen inches greater than the gauge of the track. A number of outside-connected mine locomotives have, however, also been constructed. In this pattern the width is thirty-two inches greater than the gauge of the track. A locomotive of twenty-inches gauge for a gold mine in California was built in 1876, and was found entirely practicable and efficient.

In 1870, in some locomotives for the Kansas Pacific Railway, the steel tires were shrunk on without being secured by bolts or rivets in any form, and since that time this method of putting on tires has been the rule.

In 1871 forty locomotives were constructed for the Ohio and Mississippi Railway, the gauge of which was changed from five feet six inches to four feet eight and one-half inches. The entire lot of forty locomotives was completed and delivered in about twelve weeks. The gauge of the road was changed on July 4, and the forty locomotives went at once into service in operating the line on the standard gauge.

During the same year two "double-end" engines of Class 10–26¼ C, as described in catalogue, were constructed for the Central Railroad of New Jersey, and were the first of this pattern at these works.

The product of the works, which had been steadily increasing for some years in sympathy with the requirements of the numerous new railroads which were constructing, reached three hundred and thirty-one locomotives in 1871, and four hundred and twenty-two in 1872. Orders for ninety locomotives for the Northern Pacific Railroad were entered during 1870–71, and for one hundred and twenty-four for the Pennsylvania Railroad during 1872–73, and mostly executed during those years. A contract was also made during 1872 with the Veronej-Rostoff Railway of Russia for ten locomotives to burn Russian anthracite coal. Six were "Moguls," with cylinders nineteen by twenty-four, and driving-wheels four and one-half feet diameter; and four were passenger locomotives, "American" pattern, with cylinders seventeen by twenty-four, and driving-wheels five and one-half feet diameter. Nine "American" pattern locomotives, fifteen by twenty-four cylinders, and five-feet driving-wheels, were also constructed in 1872–73 for the Hango-Hyvinge Railway of Finland.

Early in 1873, Mr. Baird sold his interest in the works to his five partners, and a new firm was formed under the style of Burnham, Parry, Williams & Co., dating from January 1 of that year. Mr. John H. Converse, who had been connected with the works since 1870, became a member of the new firm. The product of this year was four hundred and thirty-seven locomotives, the greatest in the history of the business. During a part of the year ten locomotives per week were turned out. Nearly three thousand men were employed. Forty-five locomotives for the Grand Trunk Railway of Canada were built in August, September, and October, 1873, and all were delivered in five weeks after shipment of the first.

As in the case of the Ohio and Mississippi Railway, previously noted, these were to meet the requirements of a change of gauge from five and one-half feet to four feet eight and one-half inches. Two "Consolidation" locomotives were sent in September, 1873, to the Mexican Railway. These had cylinders twenty by twenty-four; driving-wheels, forty-nine inches in diameter; and weighed, loaded, about ninety-five thousand pounds each, of which about eighty-two thousand pounds were on the driving-wheels. These engines hauled in their trial trips, without working to their full capacity, five loaded cars up the four per cent. grades of the Mexican Railway. In November, 1873, under circumstances of especial urgency, a small locomotive for the Meier Iron Company of St. Louis was wholly made from the raw material in sixteen working days.

The financial difficulties which prevailed throughout the United States, beginning in September, 1873, and affecting chiefly the railroad interests and all branches of manufacture connected therewith, have operated of course to curtail the production of locomotives since that period. Hence, only two hundred and five locomotives were built in 1874, and one hundred and thirty in 1875. Among these may be enumerated two sample locomotives for burning anthracite coal (one passenger, sixteen by twenty-four cylinders, and one "Mogul" freight, eighteen by twenty-four cylinders) for the Technical Department of the Russian Government; also, twelve "Mogul" freight locomotives, nineteen by twenty-four cylinders, for the Charkoff Nicolaieff Railroad of Russia. A small locomotive to work by compressed air, for drawing street cars, was constructed during 1874 for the Compressed Air Locomotive and Street Car Company of Louisville, Ky. It had cylinders seven by twelve, and four wheels coupled, thirty inches in diameter. Another and smaller locomotive to work by compressed air was constructed three years later for the Plymouth Cordage Company of Massachusetts, for service on a track in and about their works. It had cylinders five by ten, four wheels coupled twenty-four inches diameter, weight, seven thousand pounds, and has been successfully employed for the work required.

The year 1876, noted as the year of the Centennial International Exhibition in Philadelphia, brought some increase of business, and two hundred and thirty-two locomotives were constructed. An exhibit consisting of eight locomotives was prepared for this occasion. With the view of illustrating not only different types of American locomotives, but the practice of different railroads, the exhibit consisted chiefly of locomotives constructed to fill orders from various railroad companies of the United States and from the Imperial Government of Brazil. A "Consolidation" locomotive for burning anthracite coal, for the Lehigh Valley Railroad, for which line the first locomotive of this type was designed and built in 1866; a similar locomotive, to burn bituminous coal, and a passenger locomotive for the same fuel for the Pennsylvania Railroad; a "Mogul" freight locomotive, the "Principe do Grão Pará," for the D. Pedro Segundo Railway of Brazil; and a passenger locomotive (anthracite burner) for the Central Railroad of New Jersey, comprised the larger locomotives contributed by these works to the Exhibition of 1876. To these were added a mine locomotive and two narrow

(three feet) gauge locomotives which were among those used in working the Centennial Narrow-Gauge Railway. As this line was in many respects unique, we subjoin the following extracts from an account by its General Manager of the performance of the two three-feet gauge locomotives:

"The gauge of the line was three feet, with double track three and a half miles long, or seven miles in all. For its length it was probably the most crooked road in the world, being made up almost wholly of curves, in order to run near all the principal buildings on the Exhibition grounds. Many of these curves were on our heaviest grades, some having a radius of 215, 230, and 250 feet on grades of 140 and 155 feet per mile. These are unusually heavy grades and curves, and when *combined* as we had them, with only a thirty-five pound iron rail, made the task for our engines exceedingly difficult.

"Your locomotive 'Schuylkill,' Class 8–18 C (eight-wheeled, four wheels coupled three and a half feet diameter, cylinders twelve by sixteen, weight forty-two thousand six hundred and fifty pounds), began service May 13, and made one hundred and fifty-six days to the close of the Exhibition. The locomotive 'Delaware,' Class 8–18 D (eight-wheeled, six wheels coupled three feet diameter, cylinders twelve by sixteen, weight thirty-nine thousand pounds), came into service June 9, and made one hundred and thirty-one days to the close of the Exhibition. The usual load of each engine was five eight-wheeled passenger cars, frequently carrying over one hundred passengers per car. On special occasions as many as six and seven loaded cars have been drawn by one of these engines.

"Each engine averaged fully sixteen trips daily, equal to fifty-six miles, and, as the stations were but a short distance apart, the Westinghouse air-brake was applied in making one hundred and sixty daily stops, or a total of twenty-five thousand for each engine. Neither engine was out of service an hour unless from accidents for which they were in no way responsible."

[Note.—Average weight of each loaded car about twelve gross tons.]

The year 1876 was also marked by an extension of locomotive engineering to a new field in the practice of these works. In the latter part of the previous year an experimental steam street car was constructed for the purpose of testing the applicability of steam to street railways. This car was completed in November, 1875, and was tried for a few days on a street railway in Philadelphia. It was then sent to Brooklyn, December 25, 1875, where it ran from that time until June, 1876. One engineer ran the car and kept it in working order. Its consumption of fuel was between seven and eight pounds of coal per mile run. It drew regularly, night and morning, an additional car, with passengers going into New York in the morning and returning at night. On several occasions, where speed was practicable, the car was run at the rate of sixteen to eighteen miles per hour.

In June, 1876, this car was withdrawn from the Atlantic Avenue Railway of Brooklyn, and placed on the Market Street Railway of Philadelphia. It worked with fair success, and very acceptably to the public on that line, from June till nearly the close of the Centennial Exhibition.

This original steam-car was built with cylinders under the body of the car, the connecting-rods taking hold of a crank-axle, to which the front wheels were attached. The rear wheels of the car were independent, and not coupled with the front wheels. The machinery of the car was attached to an iron bed-plate bolted directly to the wooden framework of the car body. The experiment with

this car demonstrated to the satisfaction of its builders the mechanical practicability of the use of steam on street railways, but the defects developed by this experimental car were: first, that it was difficult, or impossible, to make a crank-axle which would not break, the same experience being reached in this respect which had already presented itself in locomotive construction; second, it was found that great objection existed to attaching the machinery to the wooden car body, which was not sufficiently rigid for the purpose, and which suffered by being racked and strained by the working of the machinery.

For these reasons this original steam-car was reconstructed, in accordance with the experience which nearly a year's service had suggested. The machinery was made "outside-connected," the same as in an ordinary locomotive, and a strong iron framework was designed, entirely independent of the car body, and supporting the boiler and all the machinery.

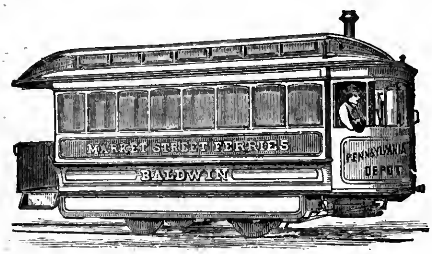


FIG. 15.

The car as thus reconstructed was named the "Baldwin," and is shown by Figure 15.

The next step in this direction was the construction of a separate "motor" (Figure 16), to which one or more cars could be attached. Such a machine, weighing about sixteen thousand pounds, was constructed in the fall of 1876, and sent to the Citizens' Railway of Baltimore, which has maximum grades of

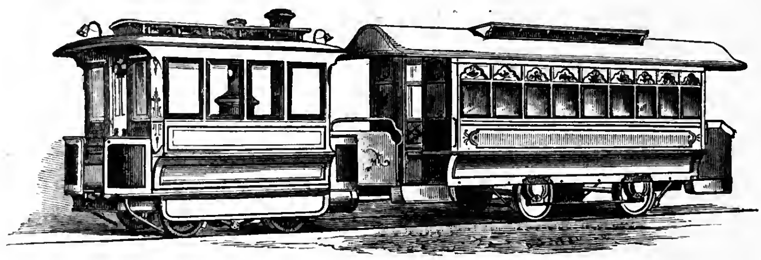


FIG. 16.

seven feet per hundred, or $369\frac{6}{10}$ feet per mile. It ascended the three hundred and sixty-nine feet grade, drawing one loaded car, when the tracks were covered with mixed snow and dirt to a depth of eight to ten inches in places. Another and smaller motor, weighing only thirteen thousand pounds, was constructed about the same time for the Urbano Railway, of Havana, Cuba. Orders for other similar machines followed, and during the ensuing years 1877–78–79–80 one hundred and seven separate motors and twelve steam-cars were included in the product. Various city and suburban railways have been constructed with the especial view of employing steam-power, and have been equipped with these machines. One line, the Hill & West Dubuque Street Railway, of Dubuque, Iowa, was constructed early in 1877, of three and a half feet gauge, with a maximum gradient of nine in one hundred, and has been worked exclusively by two of these

motors. Sections of the Brooklyn City Railway, the Bushwick Railway, and the Broadway Railroad, of Brooklyn, are also operated by these machines, and on these lines eight-wheeled street cars, each seating forty passengers, are employed. The details and character of construction of these machines are essentially the same as locomotive work, but they are made so as to be substantially noiseless, and to show little or no smoke and steam in operation.

Steel fire-boxes with vertical corrugations in the side sheets were first made by these Works early in 1876, in locomotives for the Central Railroad of New Jersey, and for the Delaware, Lackawanna and Western Railway.

The first American locomotives for New South Wales and Queensland were constructed by the Baldwin Locomotive Works in 1877, and were succeeded by additional orders in 1878 and 1879. Six locomotives of the "Consolidation" type for three and one-half feet gauge were also constructed in the latter year for the Government Railways of New Zealand, and two freight locomotives, six-wheels-connected with forward truck, for the Government of Victoria. Four similar locomotives (ten-wheeled, six-coupled, with sixteen by twenty-four cylinders) were also built during the same year for the Norwegian State Railways.

Forty heavy "Mogul" locomotives (nineteen by twenty-four cylinders, driving-wheels four and one-half feet in diameter) were constructed early in 1878 for two Russian Railways (the Koursk Charkof Azof, and the Orel Griazi). The definite order for these locomotives was only received on the sixteenth of December, 1877, and as all were required to be delivered in Russia by the following May, especial despatch was necessary. The working force was increased from eleven hundred to twenty-three hundred men in about two weeks. The first of the forty engines was erected and tried under steam on January 5th, three weeks after receipt of order, and was finished, ready to dismantle and pack for shipment, one week later. The last engine of this order was completed February 13th. The forty engines were thus constructed in about eight weeks, besides twenty-eight additional engines on other orders, which were constructed wholly or partially, and shipped during the same period.

In December, 1878, the heaviest locomotive ever built at these Works was completed for the New Mexico and Southern Pacific Railroad (four feet eight and one-half inches gauge), an extension of the Atcheson, Topeka and Santa Fé Railway. It was of the "Consolidation" type, was named "Uncle Dick," and was of the following general dimensions: Cylinders, twenty by twenty-six inches; driving-wheels, forty-two inches diameter, four pairs connected; truck-wheels, thirty inches diameter, one pair; total wheel-base, twenty-two feet ten inches; wheel-base of flanged driving-wheels, nine feet; capacity of water-tank on boiler, twelve hundred gallons; capacity of water-tank of separate tender, twenty-five hundred gallons; weight of engine in working-order, including water in tank, one hundred and fifteen thousand pounds; weight on driving-wheels, one hundred thousand pounds.

This locomotive was built for working a temporary switchback track (used during the construction of a tunnel) crossing the Rocky Mountains, with maxi-

mum grades of six in one hundred. Over these grades the engine hauled its loaded tender (forty-four thousand pounds) and nine loaded cars (each forty-three thousand pounds): total load, exclusive of its own weight, four hundred and thirty-one thousand pounds. On a grade of two per cent. it hauled a train weighing nine hundred and sixty-five thousand pounds, and on one of three and a half per cent., five hundred and seventeen thousand pounds. Curves of sixteen degrees occurred on the switchback track, but not in combination with the six per cent. grades.

The production during the nine years from 1872 to 1880 inclusive was as follows:

1872	. . .	422	locomotives.
1873	. . .	437	"
1874	. . .	205	"
1875	. . .	130	"
1876	. . .	232	"
1877	. . .	185	"
1878	. . .	292	"
1879	. . .	398	"
1880	. . .	515	" (partly estimated)

Four tramway motors of twelve tons weight were built early in 1879, on the order of the New South Wales Government, for a tramway having grades of six per cent., and running from the railway terminus to the Sydney Exhibition Grounds. During the next year orders followed for twenty-nine additional motors for other tramways in Sydney.

The year 1880 was marked by the largest production in the history of the Works, and the character of the product reflects the growing demand for larger and more powerful locomotives. One hundred and thirty-one "Consolidation" engines were comprised in the list, of which sixty were of narrow gauge and seventy-one of the standard and broad gauges. Included in the product were two "Consolidation" engines for five feet three inches track for the Government Railways of South Australia, and two nineteen by twenty-four cylinders, ten-wheeled engines, six coupled, for the same lines. For the three and one-half feet gauge lines of the same Government, eight "Mogul" locomotives, fourteen and one-half by eighteen cylinders, and driving-wheels thirty-nine inches in diameter, were supplied at the same time. Ten "Consolidation" locomotives of larger dimensions than had been previously built (viz.: twenty by twenty-eight cylinders, and weighing loaded about one hundred and fifteen thousand pounds) were constructed for the Atcheson, Topeka and Santa Fé Railway, and twenty-eight "Consolidation" locomotives of the ordinary size (twenty by twenty-four cylinders), but with Wootten's patent fire-boxes, were made for the Philadelphia and Reading Railroad during the year.

The five thousandth locomotive, finished in April, 1880, presented some novel features. It was designed for fast passenger service on the Bound Brook line

between Philadelphia and New York, and to run with a light train at a speed of sixty miles per hour, using anthracite coal as fuel. It had cylinders eighteen by twenty-four, one pair of driving-wheels six and one-half feet in diameter, and a pair of trailing-wheels forty-five inches in diameter, and equalized with the driving-wheels. Back of the driving-wheels and over the trailing-wheels space was given for a wide fire-box (eight feet long by seven feet wide inside) as required for anthracite coal. By an auxiliary steam cylinder placed under the waist of the boiler, just in front of the fire-box, the bearings on the equalizing beams between trailing and driving-wheels could be changed to a point forward of their normal position, so as to increase the weight on the driving-wheels when required. The adhesion could thus be varied between the limits of thirty-five thousand to forty-five thousand pounds on the single pair of driving-wheels. This feature of the locomotive was made the subject of a patent. Particulars of this locomotive and its performance will be found on pages 78 to 81 of the Catalogue.

The record of the Baldwin Locomotive Works has thus been given for nearly a half-century of existence and continuous operation. Over five thousand locomotives have been constructed since the "Old Ironsides" of 1831. That engine was nearly a year in building; and the one thousandth locomotive was only completed in 1861, making an average of only thirty-three annually for the first thirty years; the two thousandth locomotive was turned out in 1869, the three thousandth in 1872, the four thousandth in 1876, and the five thousandth in 1880. The present capacity of the Works is equal to ten locomotives per week. Nine acres of ground are occupied by the various buildings and yards used in the business. The location, in the largest manufacturing city in America, gives especial facilities and advantages. Proximity to the principal coal and iron regions of the country renders all required materials promptly available. A large permanent population of skilled mechanics employed in similar branches in other Philadelphia workshops gives an abundant force of expert workmen from which to draw when necessary. The maximum force is from two thousand six hundred to three thousand men when the Works are employed to their full capacity. All parts of locomotives and tenders, except the boiler and tank plates, the steel tires and steel forgings, chilled wheels, boiler tubes, and some of the furniture, are made in the Works from the raw materials. The plant comprises seven hundred and thirty-four machine tools, many of them designed and constructed to meet the special requirements of locomotive work. Drawings and patterns for over five hundred different sizes or patterns of locomotives for all existing gauges and every description of service are included in the working lists. For particulars of the principal standard classes, attention is invited to the Catalogue.

CATALOGUE.

CIRCULAR.

In the following pages we present and illustrate a system of STANDARD LOCOMOTIVES, in which, it is believed, will be found designs suited to all the requirements of ordinary service.

These patterns admit of modifications, to suit the preferences of railroad managers, and where machines of peculiar construction for special service are required, we are prepared to make and submit designs, or to build to specifications furnished.

All the locomotives of the system herewith presented are adapted to the consumption of wood, coke, or bituminous coal as fuel. For anthracite coal a modification in the form of fire-box is necessary in the principal classes.

All work is accurately fitted to gauges, which are made from a system of standards kept exclusively for the purpose. Like parts will, therefore, fit accurately in all locomotives of the same class.

This system of manufacture, together with the large number of locomotives at all times in progress, and embracing the principal classes, insures unusual and especial facilities for filling at once, or with the least possible delay, orders for duplicate parts.

The advantages and economies to the *users of locomotives* resulting from this method of construction are apparent. By its means the expense of maintenance and repairs can be reduced to a minimum. A limited stock of duplicate parts, either ordered with the locomotive or at any time thereafter, can be kept on hand by the purchaser and drawn from to replace any worn-out or broken part when required. Repairs can thus be made in the shortest possible time, and the use of the locomotive lost for only a few hours or days, or not at all. The first cost of duplicates will be much less than the cost of manufacture in the shop of the

railroad company; in many cases it will be less than the cost of carrying the stock of raw material necessary for the purpose; while, if the line is equipped with a limited number of classes of standard interchangeable locomotives, the quantity of duplicates necessarily carried in stock will be small and comparatively inconsiderable in the amount of capital represented. Much of the ordinary outlay for shops, machinery, drawings, and patterns can be saved, and the necessity of maintaining for the purpose of repairs a large force of skilled workmen at a constant expense may be in great measure obviated.

Particulars of the performance of various classes of locomotives illustrated will be found in the body of the Catalogue. It will be seen from these statements of work actually done that fully one-fourth the weight on driving-wheels is utilized for adhesion, under ordinarily favorable conditions, with adequate boiler and cylinder capacity. The loads given in the tables are, therefore, calculated for each class on this basis, in tons of twenty-two hundred and forty pounds, and are predicated on track being straight and in good condition. It is also assumed that the frictional resistance of the cars hauled will not exceed seven pounds per gross ton of their weight.

Designs and estimates for any sizes or patterns of locomotives not given in this Catalogue will be submitted on application.

The delivery of locomotives at any point which can be reached by rail or vessel will be included in contracts if desired.

In ordering locomotives, the following particulars should be given:

1. Gauge of track,—exact distance between the rails.
2. Kind of fuel which will be used.
3. Kind and height of couplings of cars.
4. Limitations, if any, in width, height, etc., by tunnels, overhead bridges, etc.
5. Mark, name, or number.

For detailed specifications and further particulars, address

BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS,

PHILADELPHIA, PA.

CLASS DESIGNATIONS.

The different classes of locomotives are designated by a combination of figures with one of the letters A, C, D, or E, so as to indicate both the plan and size, as follows:

The letter A indicates that only one pair of wheels are driving-wheels.
" " C " " four wheels are connected as "
" " D " " six " " "
" " E " " eight " " "

1. A figure (4, 6, 8, or 10) is used to indicate the whole number of wheels under the locomotive.

2. A figure or figures, following the figures indicating the whole number of wheels, indicates the diameter of cylinders, viz.:

12	indicates	cylinders	9	inches	in diameter.
14	"	"	10	"	"
16	"	"	11	"	"
18	"	"	12	"	"
20	"	"	13	"	"
22	"	"	14	"	"
24	"	"	15	"	"
26	"	"	16	"	"
28	"	"	17	"	"
30	"	"	18	"	"
32	"	"	19	"	"
34	"	"	20	"	"
36	"	"	21	"	"

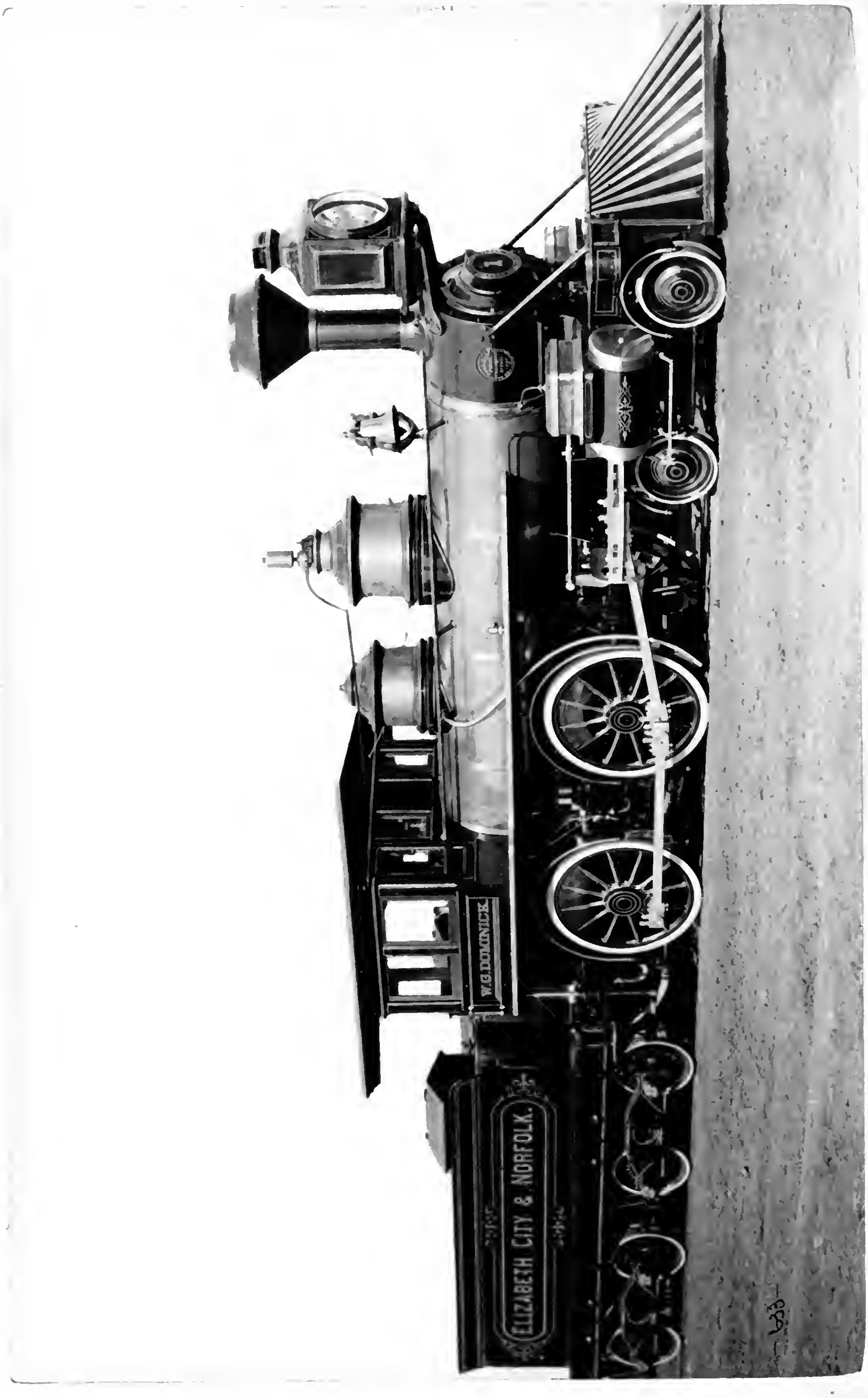
Thus 8–26 C indicates an eight-wheeled locomotive, having four wheels coupled, and cylinders sixteen inches in diameter. 8–26 D indicates an eight-wheeled locomotive, having six wheels coupled, and cylinders of the same diameter; and 10–34 E, a ten-wheeled locomotive, having eight wheels coupled, and cylinders twenty inches in diameter.

The addition of the fraction ¼ indicates that there is a truck at each end of the locomotive. Thus 8–26¼ C indicates an eight-wheeled locomotive, having four wheels coupled, cylinders sixteen inches in diameter, and a two-wheeled truck at each end.

The addition of the fraction ⅓ indicates that the engine is on the "Forney" plan, having the truck back of the fire-box. Thus 8–26⅓ C indicates an eight-

wheeled locomotive, having four wheels coupled, cylinders sixteen inches in diameter, and a four-wheeled truck back of the fire-box. 6–26⅓ C indicates a six-wheeled locomotive, having four wheels coupled, cylinders sixteen inches in diameter, and a two-wheeled truck back of the fire-box.

The figures following the class designation, as found on every locomotive, give the *class number* for that locomotive, and supply an individual designation for it, in addition to the construction number. Thus, 8–26 C 500 means the five-hundredth locomotive of the 8–26 C class.


W. G. DOMINICK
ELIZABETH CITY & NORFOLK.

LIGHT PASSENGER LOCOMOTIVES, "AMERICAN" TYPE,

FOR TRACKS LAID WITH RAILS WEIGHING 30 TO 40 POUNDS PER YARD.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Photograph on page 62.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
									On a Level.	On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-14 C	10 × 20	45 to 51	5 6	16 4		1000	36,000	21,000	500	220	130	85	60	45	35
8-16 C	11 × 22	45 to 51	6	18 3		1200	42,000	26,000	685	290	170	110	80	60	45
8-18 C	12 × 22 or 24	48 to 54	6 6	19 1		1400	46,000	30,000	860	375	215	145	105	80	65

These classes are offered as suitable for passenger traffic on tracks of standard or wide gauge laid with light rails.

The following minimum weights of rails are recommended as suitable: for Class 8-14 C, 30 pounds per yard; for Class 8-16 C, 35 pounds per yard; and for Class 8-18 C, 40 pounds per yard.

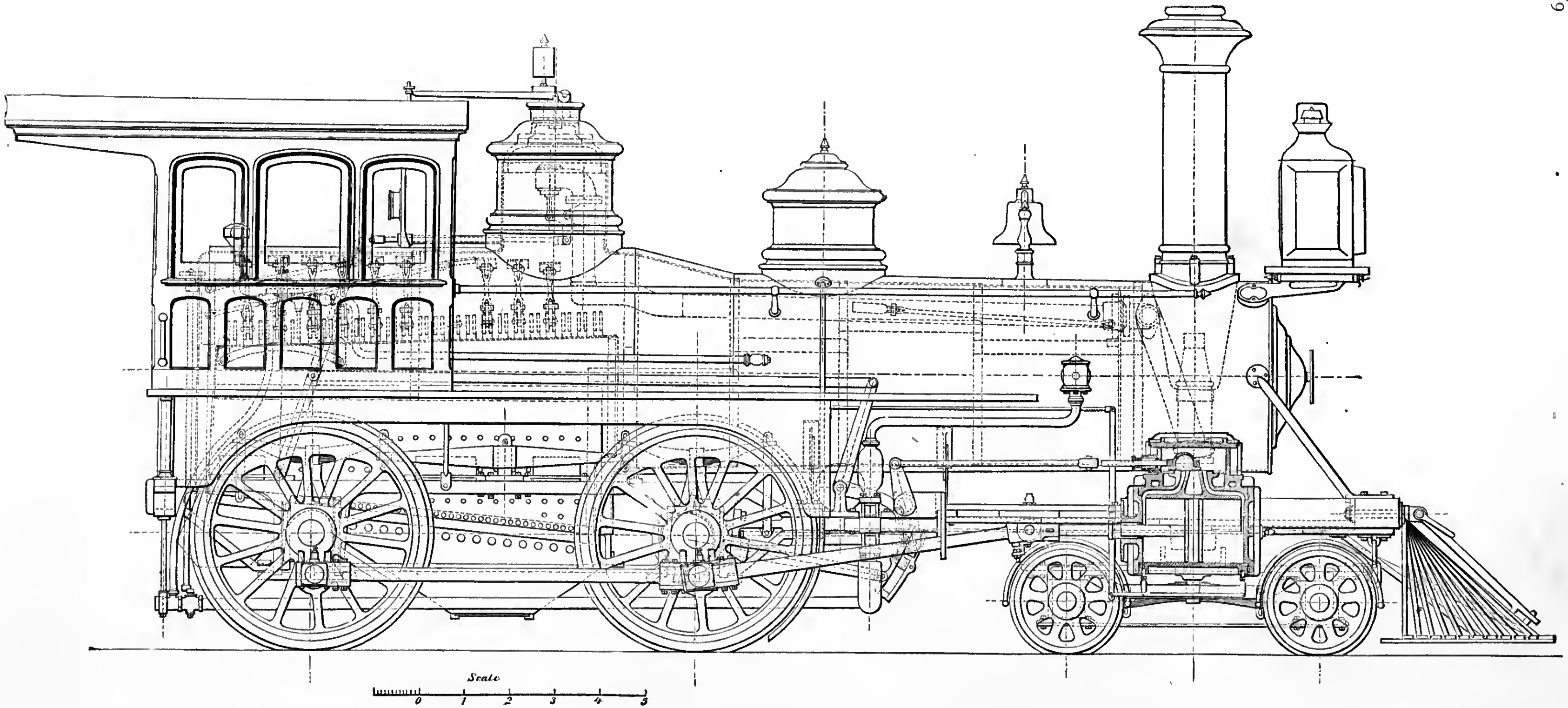
The total wheel-base of engine and tender varies from 31 feet 2 inches for Class 8-14 C, with 4-wheeled tender, to 38 feet 11 inches for Class 8-18 C, with 8-wheeled tender. From 18 inches to 2 feet should be added to these figures to give the length of turn-table required.

LIGHT PASSENGER LOCOMOTIVES.

The classes of locomotives described on preceding page are of substantially the same weight as similar classes constructed for narrow-gauge railways and in use on light rails.

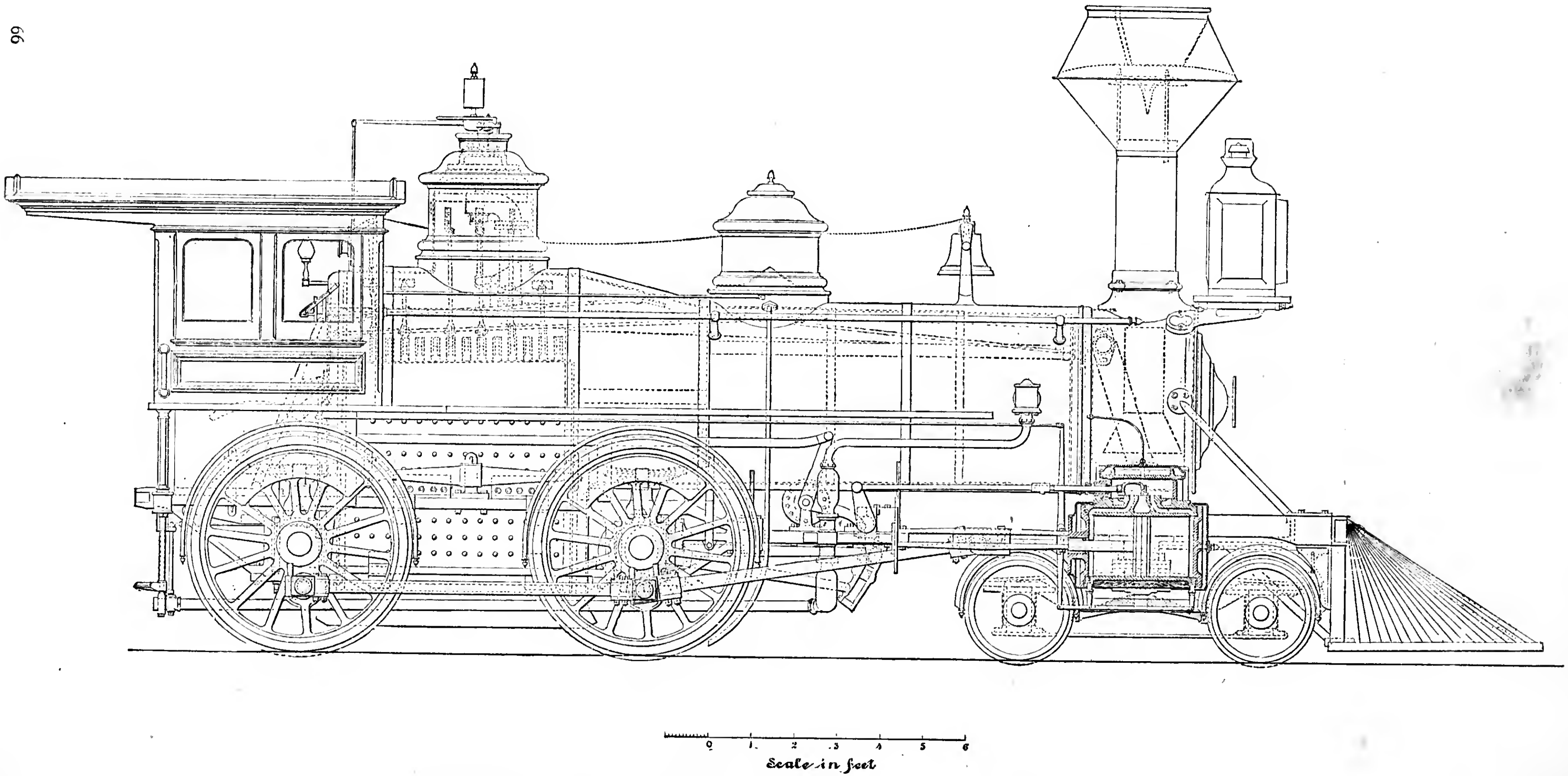
The engine truck can be made with or without swinging bolster, as preferred. The short driving-wheel base permits curves of short radius to be passed without difficulty.

The tenders up to 1200 gallons capacity can be made 4-wheeled, if desired, and all the tenders can be made 6-wheeled instead of 8-wheeled, if preferred.

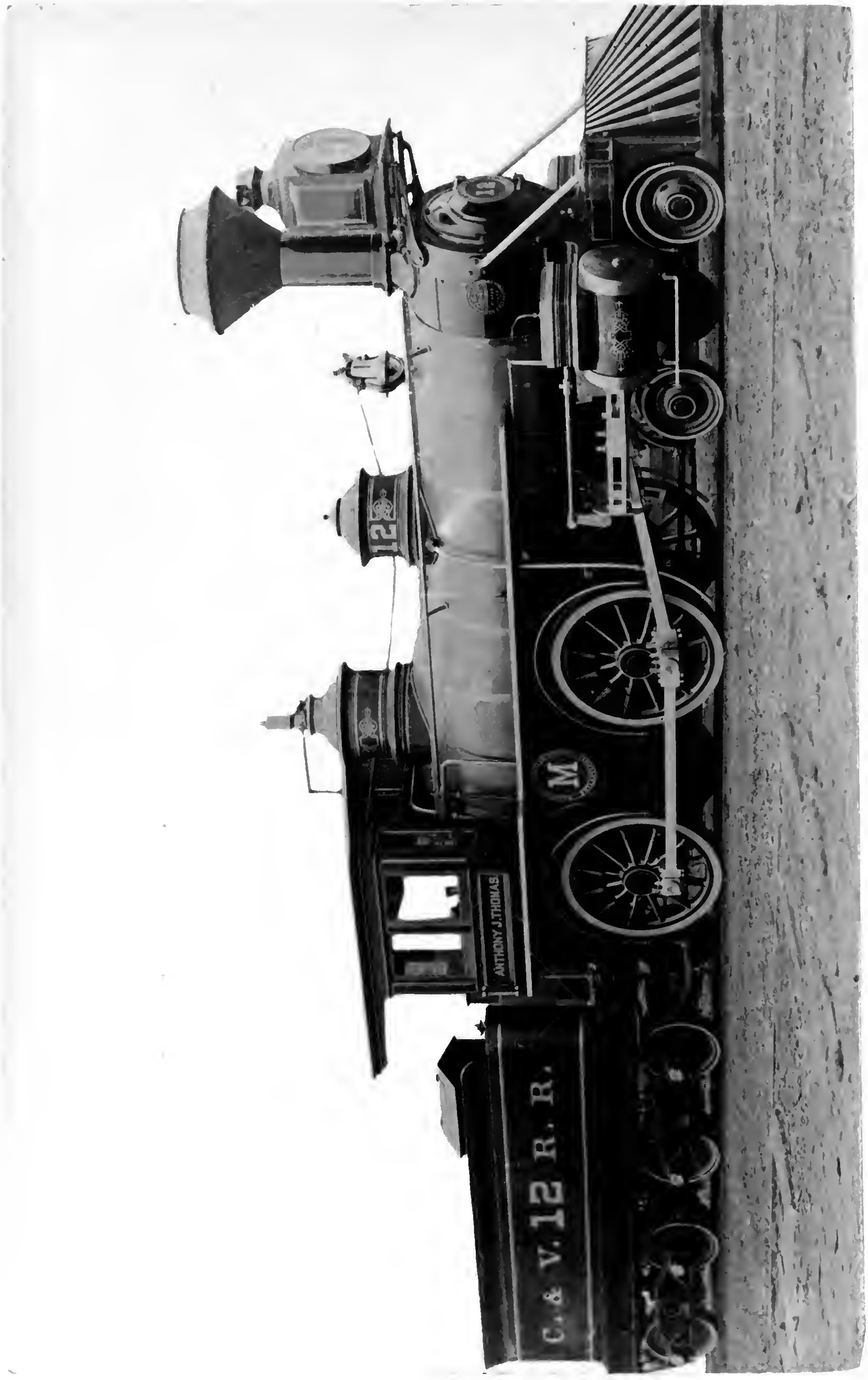


PASSENGER AND FREIGHT LOCOMOTIVE, "AMERICAN" TYPE.

Fuel, Anthracite Coal.



PASSENGER AND FREIGHT LOCOMOTIVE, "AMERICAN" TYPE.
Fuel, Wood or Bituminous Coal.


C. & V. 12 R. R.
ANTHONY J. THOMAS
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12

PASSENGER AND FREIGHT LOCOMOTIVES, "AMERICAN" TYPE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Engraving and Photograph on pages 66 and 68.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-20 C	13 × 22 or 24	49 to 57	7	20 6		1400	56,000	35,000	1000	435	255	170	125	95	75
8-22 C	14 × 22 or 24	55 to 61	7 4	20 11		1600	59,000	38,000	1100	470	275	185	135	105	80
8-24 C	15 × 22 or 24	55 to 66	7 8	21 3		1800	62,000	40,000	1150	495	290	195	145	110	85
8-26 C	16 × 22 or 24	55 to 66	8	21 9		2000	66,000	43,000	1240	535	310	210	155	120	95
8-28 C	17 × 22 or 24	55 to 66	8 3	22 2		2200	70,000	46,000	1325	575	335	225	165	125	100
8-30 C	18 × 22 or 24	61 to 66	8 6	22 5		2400	74,000	49,000	1400	610	355	240	175	135	110

The total wheel-base of engine with 8-wheeled tender attached varies from 40 feet for Class 8-20 C to 43 feet for Class 8-30 C. From 18 inches to 2 feet should be added to these figures, for clearance of flanges of extreme wheels, to give the minimum length of turn-table admissible.

Where anthracite coal is used as the fuel a different form of fire-box is required, as shown in line drawing on page 65. This form of fire-box increases the total length of boiler, and adds from 4000 to 5000 pounds to the total loaded weight of locomotive. From three-fourths to four-fifths of this increased weight is carried on the driving-wheels.

PERFORMANCE OF LOCOMOTIVES, "AMERICAN" TYPE.

THE passenger traffic of American railroads is worked almost universally with engines of this pattern, and the same type of locomotives is also used for freight service on many lines with easy grades, or where the tonnage is comparatively light, or is hauled at a speed of more than fifteen miles per hour.

In order to indicate the tractive power exerted in actual service by such locomotives, a few instances are given below:

CLASS 8-20 C ON GRADE OF 72 FEET PER MILE.

MACON AND BRUNSWICK RAILROAD.

SUPERINTENDENT'S OFFICE, MACON, GA., February 15, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Dear Sirs,—Replying to yours of February 11th, I take pleasure in saying your engineer was correct as to hauling with the locomotive "Governor A. H. Colquitt" 12 loaded flat cars and an 8-wheeled caboose over a 72′ grade, with curve of 2°.

Engineer says it will now pull 15 loaded box cars and caboose.

Yours, very respectfully,

GEO. W. ADAMS,
General Superintendent.

CLASS 8-22 C ON GRADE OF 53 FEET PER MILE.

WESTERN RAILROAD OF ALABAMA.

OFFICE OF GENERAL MANAGER, MONTGOMERY, ALA., January 16, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Engines "Georgia" and "Alabama" made by you (14″ × 24″ cylinders, 60,000 lbs. weight), will carry 15 loaded cars and caboose up our Notasulza grade of 1′ in 100′.

Very truly yours,

E. P. ALEXANDER,
General Manager.

CLASS 8-22 C ON GRADE OF 71 FEET PER MILE.

MACON AND BRUNSWICK RAILROAD.

OFFICE OF MASTER MACHINIST, MACON, GA., March 21, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—On March 19th the locomotive "James M. Smith" arrived in Macon. This morning it made its trial trip, and, I am glad to say, worked satisfactorily. It pulled with ease 18 cars loaded with green pine wood up a grade of 71′ per mile.

GEO. R. WAGNON,
Master Machinist.

CLASS 8-24 C ON GRADE OF 237 FEET PER MILE.

SPARTANBURG, UNION AND COLUMBIA RAILROAD.

SUPERINTENDENT'S OFFICE, SPARTANBURG, S. C., May 19, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The locomotive "W. H. Inman," No. 5 (cylinders 15″ × 22″, driving-wheels 50″ diameter), came duly to hand, and has been put up and tested by your mechanic. We tried it with a train of 2 first-class passenger coaches and 1 mail and baggage car of the usual weight. It carried them up our 237′ grade finely, although the rail was wet.

JAMES ANDERSON,
Superintendent.

CLASS 8-26 C ON GRADE OF 42 FEET PER MILE.

On the Atlanta and West Point Railroad, locomotives of Class 8-26 C (cylinders 16″ × 24″, driving-wheels 56″ diameter) haul, each, 23 to 25 loaded cars (average weight of each loaded car about 16 gross tons) over maximum grades of 42′ per mile.

CLASS 8-26 C ON GRADE OF 65 FEET PER MILE.

ATLANTA AND CHARLOTTE AIR-LINE RAILWAY.

OFFICE OF GENERAL MANAGER, ATLANTA, GA., February 4, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The maximum grades on this line are of considerable length and 65′ per mile on tangents, with a reduction on curves equalizing them to 65′ on tangents. The loads for the freight locomotives constructed by you for this company are on dry rail over the whole line 16 loaded cars. On many parts of the line they pull 20 loaded cars.

G. J. FOREACRE,
General Manager.

CLASS 8-28 C ON GRADE OF 47 7-10 FEET PER MILE.

KANSAS PACIFIC RAILWAY.

OFFICE SUPERINTENDENT MACHINERY, ARMSTRONG, KAN., December 12, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Engine No. 90 (cylinders 17″ × 24″, driving-wheels 58″ diameter) on second trip brought into this point 41 loaded cars, with an average of 11 tons per car, and this over a grade of $47\frac{7}{10}$′ per mile.

JOHN MACKENZIE,
Superintendent Machinery.

CLASS 8-28 C ON GRADE OF 40 FEET PER MILE.

MISSOURI, KANSAS AND TEXAS RAILWAY.

OFFICE OF SUPERINTENDENT OF MACHINERY, SEDALIA, MO., March 18, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—In reply to your inquiry as to the performance of the 17″ × 24″ cylinder, "American" pattern, locomotives constructed by your works for this line, I would say that the engines referred to haul, each, 20 loaded cars and 1 caboose over a grade of 70′ per mile, with a pressure of 135 lbs.

The cars are loaded with 12 tons of grain (24,000 lbs.). *Each car* is weighed *en route* and the average holds very good. Each empty car will average 19,500 lbs., which is also about the weight of the caboose.

This gives a total load of $444\frac{15}{20}$ tons, and, as reports of engine performance go, it is a very good record indeed.

Yours truly,
(*Signed*) GEO. W. CUSHING,
Superintendent of Machinery.

CLASS 8-28 C, ANTHRACITE-BURNING, IN PASSENGER SERVICE.

(NOTE.—Weight of 17″ x 24″ cylinder, Anthracite Engine, about 77,000 lbs. Weight on driving-wheels about 52,000 lbs.)

LONG ISLAND RAILROAD COMPANY.

LONG ISLAND CITY, August 21, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—The 16″ × 24″ and 17″ × 24″ cylinder locomotives constructed by you for this line are giving entire satisfaction. The No. 78 (17″ × 24″) is making the run from Babylon to Hunter's Point, 38 miles, in 55 minutes, with 6 large parlor cars and baggage car, majority of them 12-wheeled cars, all full, slowing up to 15 miles per hour 5 times to run through junction switches.

Yours truly,

(*Signed*) THOS. R. SHARP,

Receiver.

LONG ISLAND RAILROAD COMPANY.

LONG ISLAND CITY, December 15, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—I have delayed until now responding to your request of September 5th, regarding the performance of Engines No. 70 and 71, for the reason that the engines were made to perform particularly trying service immediately after delivery, and it was difficult to form an estimate of their capacity with the data heretofore obtainable. I am now glad, however, to furnish you the following facts:

They hauled during the summer (and very soon after leaving your shop) trains of 300 tons, consisting of

9 excursion cars, 37,200 lbs. each	167 tons.
1000 passengers, 150 lbs. each	75 "
Engine and tender	58 "
Total	300 "

up a grade 1771′ long, averaging 107′ to the mile, at a speed of 10 miles per hour, and the engineman estimated that one additional car could have been hauled. At the foot of this grade is a curve of 225′ radius, on which the grade is 100′ to the mile.

They hauled 19 of the same excursion cars above mentioned, well filled with passengers (making a train of about 435 tons), at a speed of 25 miles per hour, from Fresh Pond Junction to Rockaway Beach.

Thirteen of these cars were taken from Long Island City to Fresh Pond Junction, a portion of this distance being a grade of 84′ to the mile with curves of 1500′ radius.

Since the close of the summer season these engines have been employed in freight service, making an average of 100 miles per day, and have frequently hauled 33 or 34 loaded freight cars (exact weight not ascertained) from Long Island City to Jamaica, over grades of 40′ to the mile, and over which piece of line 20 or 21 cars have been the maximum load for our 16″ engines.

Yours truly,

(*Signed*) S. SPENCER,

General Superintendent.

CLASS 8-28 C, ANTHRACITE-BURNING, IN PASSENGER SERVICE.

(NOTE.—Cylinders 17″ x 22″, driving-wheels 66″ diameter. Weight in working order about 77,000 lbs. Weight on driving-wheels about 52,000 lbs.)

CAMDEN AND ATLANTIC RAILROAD.

MASTER MECHANIC'S OFFICE, CAMDEN, N. J., June 3, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—I give below particulars of the performance of one of the 17″ × 22″ cylinder, 8-wheeled, 4-coupled passenger locomotives recently constructed by you for the Camden and Atlantic Railroad.

On the day that the performance stated was noted the train consisted of 6 cars, estimated to weigh as follows:

4 passenger cars (seating capacity 70 each)	179,000 lbs.
1 parlor car	49,000 "
375 passengers (average weight 135 lbs.)	50,625 "
1 baggage car	25,100 "
Full load of baggage and express goods in car	20,000 "
Weight of train exclusive of engine and tender	323,725 lbs.
" engine in working order	77,000 "
" tender loaded (3000 gallons of water)	56,000 "
Total weight of engine, tender, and train	456,725 lbs.

With this train the engine left Camden depot at 4.32 P.M., arriving at Atlantic City depot at 5.47 P.M., the distance being 58.59 miles, and the time occupied 75 minutes. The first mile, running out of Camden, took 5 minutes, including one stop for passengers. The train was once slacked up for passenger train No. 22, and the speed was once reduced to 4 miles per hour to pass through a drawbridge. The distances from station to station along the road, and the time occupied between stations, are as follows:

Camden to Haddonfield	6.74 miles,	13 minutes.	Including one stop and run out of city, as above.
Haddonfield to Kirkwood	4.66 "	6 "	
Kirkwood to Berlin	5.03 "	7 "	Grade of 27' per mile for 4½ miles.
Berlin to Atco	2.58 "	3 "	
Atco to Waterford	3.72 "	4 "	
Waterford to Winslow	4.37 "	5 "	
Winslow to Hammonton	3.15 "	4 "	
Hammonton to Elwood	6.09 "	7 "	
Elwood to Egg Harbor	4.89 "	5 "	
Egg Harbor to Pomona	5.24 "	6 "	
Pomona to Absecom	5.50 "	5½ "	
Absecom to Atlantic City	6.62 "	9½ "	Including reduced speed to pass through drawbridge, as above.
Total	58.59 miles,	75 minutes.	

The steam gauge indicated throughout the entire run a pressure of from 123 to 127 lbs., average 125 lbs., and the engine had reserve power to run faster. The time could have been reduced 5 minutes more with ease.

A stop-watch indicated that one mile was run in 60, one in 59¾, one in 59½, one in 59, one in 58¾, one in 58½, one in 57¾, and one in 58 seconds respectively.

The coal consumed during this trip was not measured, but the amount of work done with 10,000 lbs. anthracite coal, actual weight, was two round trips, Camden to Atlantic City and return, including the fast run above noted, as follows:

Sunday, left Camden with 10 cars	time, 1 hour	38 minutes.
" " Atlantic " 9 "	" 1 "	40 "
Monday, " Camden " 6 "	" 1 "	15 "
Tuesday, " Atlantic " 6 "	" 1 "	30 "

The engine steams very well and the gauge stands regular. The amount of water used was not noted.

Yours truly,

RUFUS HILL,
Master Mechanic.

The above is a correct account of the run of Engine No. 16, on Train No. 19, on May 31, 1880.

F. A. LISTER,
Superintendent.

CLASS 8-30 C ON GRADES OF 126 AND 160 FEET PER MILE.

(NOTE.—The dimensions of the locomotive referred to below are, cylinders 17″ x 24″, driving-wheels 56″ diameter, but the boiler and fire-box are of the dimensions usual in passenger engines having cylinders 18″ x 24″, and driving-wheels 5′ 2″ in diameter.)

CUMBERLAND AND PENNSYLVANIA RAILROAD COMPANY.

OFFICE OF GENERAL SUPERINTENDENT, CUMBERLAND, MD., June 5, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Dear Sirs,—Owing to pressure of business I have neglected heretofore to reply to your esteemed favor of the 25th ultimo.

In answer to the questions therein contained, I have to say that Engine No. 27 is daily engaged in drawing passenger train consisting of (usually) two passenger cars and one baggage car.

The maximum grade upon the road is 160′ continuous for a mile and a half. We have no other grade exceeding 126′ to the mile.

The engine draws its ordinary train up the 160′ grade with ease, at a speed of 15 miles an hour, and can make 20. With 4 cars attached it has no difficulty in ascending the grade. It has made the trip with 5 cars, but with that number could not exceed a rate of 10 miles an hour, even if it reached that.

The performance of the engine is satisfactory, except that it slips more and requires more sand with a train of 5 cars than was expected.

Very truly yours,

(*Signed*) P. L. BURWELL,
General Superintendent.

CLASS 8-28 C ON GRADE OF 64 FEET PER MILE.

On the Atchison, Topeka and Santa Fé Railroad, locomotives of Class 8-28 C (cylinders 17″ × 24″, driving-wheels 57″ diameter) haul, each, 20 loaded cars from Atchison to Topeka, over a maximum grade of $63\frac{89}{100}$′ per mile combined with a curve of 2°.

CLASS 8-30 C ON GRADE OF 70 FEET PER MILE.

Combined with curves of 6° and 7°.

ATLANTIC, MISSISSIPPI AND OHIO RAILROAD COMPANY.

LYNCHBURG, VA., December 31, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Gentlemen,—In response to your communication of the 9th inst., I take pleasure in stating that the three locomotives you have built for our company (your Class 8-30 C, cylinders 18″ × 24″, driving-wheels 62″ diameter) for special service with our fast mail train on our Virginia and Tennessee Mountain Division, are fully meeting the requirements of that service as guaranteed in your contract: "That such locomotives shall be capable of drawing a train of 7 passenger cars, weighing 175 tons (of 2000 lbs.), up a grade of 70′ per mile, with curves of from 6° to 7°, at a speed of from 25 to 30 miles per hour, track and cars being in good condition."

On November 6th, Engine No. 28 hauled a train consisting of 1 postal car, 1 baggage car, 4 passenger and 2 sleeping cars (total, 8 cars), weighing with load 179 tons (of 2000 lbs.), from the foot of the Alleghany Mountains, near Big Spring Station, to the summit, distance $11\frac{55}{100}$ miles, in 32 minutes, making two stops; running time, 28 minutes, or $24\frac{7}{10}$ miles per hour.

On December 5th, Engine No. 36 hauled a train consisting of 1 postal car, 2 baggage cars, 4 passenger cars, and 1 sleeping car (total, 8 cars), weighing with load, 185 tons (of 2000 lbs.), over the same portion of the road in 33½ minutes, making two stops; running time, 27 minutes, equal to $25\frac{6}{10}$ miles per hour.

The following is a statement of the gradients and curvature of the sections of our road herein referred to (the $11\frac{55}{100}$ miles of continuous grades ascending the Eastern slope of the Alleghany Mountains):

TABLE OF GRADIENTS.

Feet per mile	79.64	69.58	69.46	69.13	55.04	23.94	
Length of grade in feet .	1,200	24,600	5,100	23,500	5,400	1,208	Total length, 61,008 feet.

TABLE OF CURVATURE.

Curvature . .	7°00′	6°00′	6°10′	6°20′	6°30′	5°00′	5°10′	
Length in feet .	600	9,700	1,000	1,400	1,100	7,000	500	Total length of curves . 43,900 ft.
Curvature . .	5°30′	5°40′	5°45′	4°00′	4°30′	4°45′	3°00′	" " " straight lines, 17,108 "
Length in feet .	1,500	2,400	900	4,800	1,100	700	1,600	61.008 ft.=$11\frac{55}{100}$ mls.
Curvature . .	3°05′	3°30′	2°00′	2°30′	2°45′	1°55′	0°50′	
Length in feet .	1,200	700	2,200	500	3,100	900	1 000	

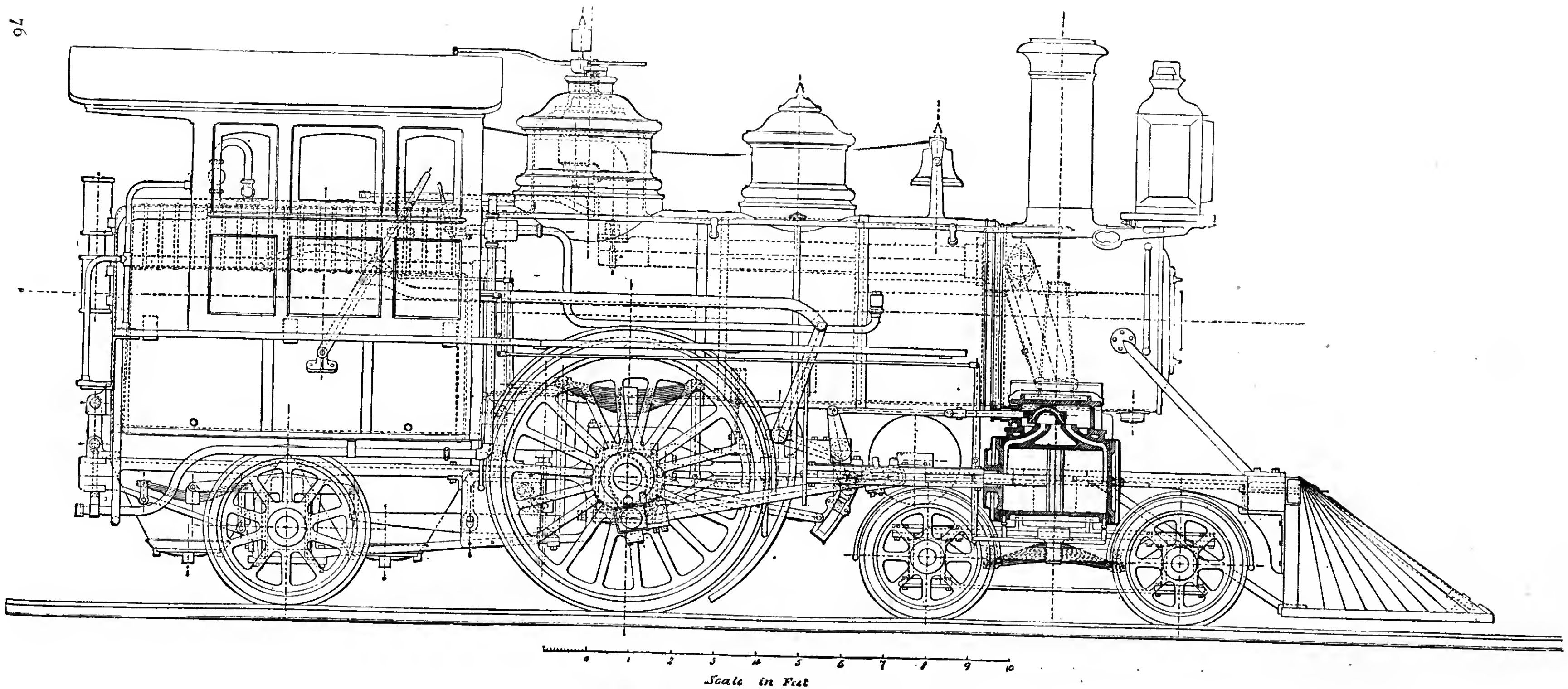
Nearly all the curves are "reversed," having no intermediate tangents.

The 6° and 7° curves occur on grades of 69.5′ and 69.1′ to the mile.

The locomotives have been in daily use for about two months, and their performance is entirely satisfactory.

Yours truly,

(*Signed*) HENRY FINK,
Receiver.



FAST PASSENGER LOCOMOTIVE.


507

FAST PASSENGER LOCOMOTIVES.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, ANTHRACITE OR BITUMINOUS COAL OR WOOD.

General Design shown by Line Drawing on page 76 and Photograph on page 78.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
									On a Level.	On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-26 A	16 × 22 or 24	66 to 72		21 1		2400	74,000	29,000	1050	440	250				
8-28 A	17 × 22 or 24	66 to 72		21 1		2800	78,000	32,000	1130	480	275				
8-30 A	18 × 22 or 24	72 to 78		21 1		3200	84,000	36,000	1280	540	310				

The weight on driving-wheels can be increased by the addition of from 8000 to 10,000 pounds by means of the appliances for transferring weight from the trailing to the driving-wheels as described on page 53. The loads in the above table are calculated on the basis of the adhesion given by the maximum weight on driving-wheels thus obtainable.

FAST PASSENGER LOCOMOTIVES.

The following letter gives particulars of the performance of a locomotive of Class 8-30 A, cylinders 18″ × 24″, driving-wheels 78″ diameter.

PHILADELPHIA AND READING RAILROAD CO.

OFFICE OF GENERAL MANAGER, PHILADELPHIA, May 17, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA:

Dear Sirs,—In response to your request, I have to state that Engine No. 507, with 4 passenger cars, made the trial run on 14th inst., from Ninth and Green Streets, Philadelphia, to Jersey City, distance 89.4 miles, in 1 hour and 38 minutes. The best performance during the trip was in running the 2.8 miles from Willett to Langhorne, part of which distance is an ascending grade of 16′ per mile, in 2 minutes.

On the return trip from Jersey City to Ninth and Green Streets, with 5 passenger cars, the run was made in 1 hour and 40 minutes.

I have no doubt that after the engine has worn smoothly upon its bearings, a higher rate of speed with the same loads can be obtained.

Respectfully,

(*Signed*) J. E. WOOTTEN,

General Manager.

The accompanying slip, showing distances and time made between stations, may be of interest to you:

Engine No. 507, Philadelphia to Jersey City,

May 14, 1880.

Station	Time	Min.
Ninth and Green	11.16 A.M.	
Wayne Junc.	11.25	9
Tabor Junc.	11.28	3
Jenkintown	11.32½	4½
Bethayres	11.36½	4
Somerton	13.39½	3
Willett	11.42½	3
Langhorne	11.44½	2
Woodburne	11.47	2½
Yardley	11.51½	4½
Trenton Junc.	11.54	2½
Pennington	11.59	5
Hopewell	12.03½	4½
Skillman	12.06½	3
Vanaken	12.10¼	3¾
Weston	12.15¼	5
Bound Brook	12.19¼	4
		63¼
Elizabeth	12.40	20¾
Jersey City	12.54	14
		98

1 hour and 38 minutes; 4 cars.

Engine No. 507, Jersey City to Philadelphia,

May 14, 1880.

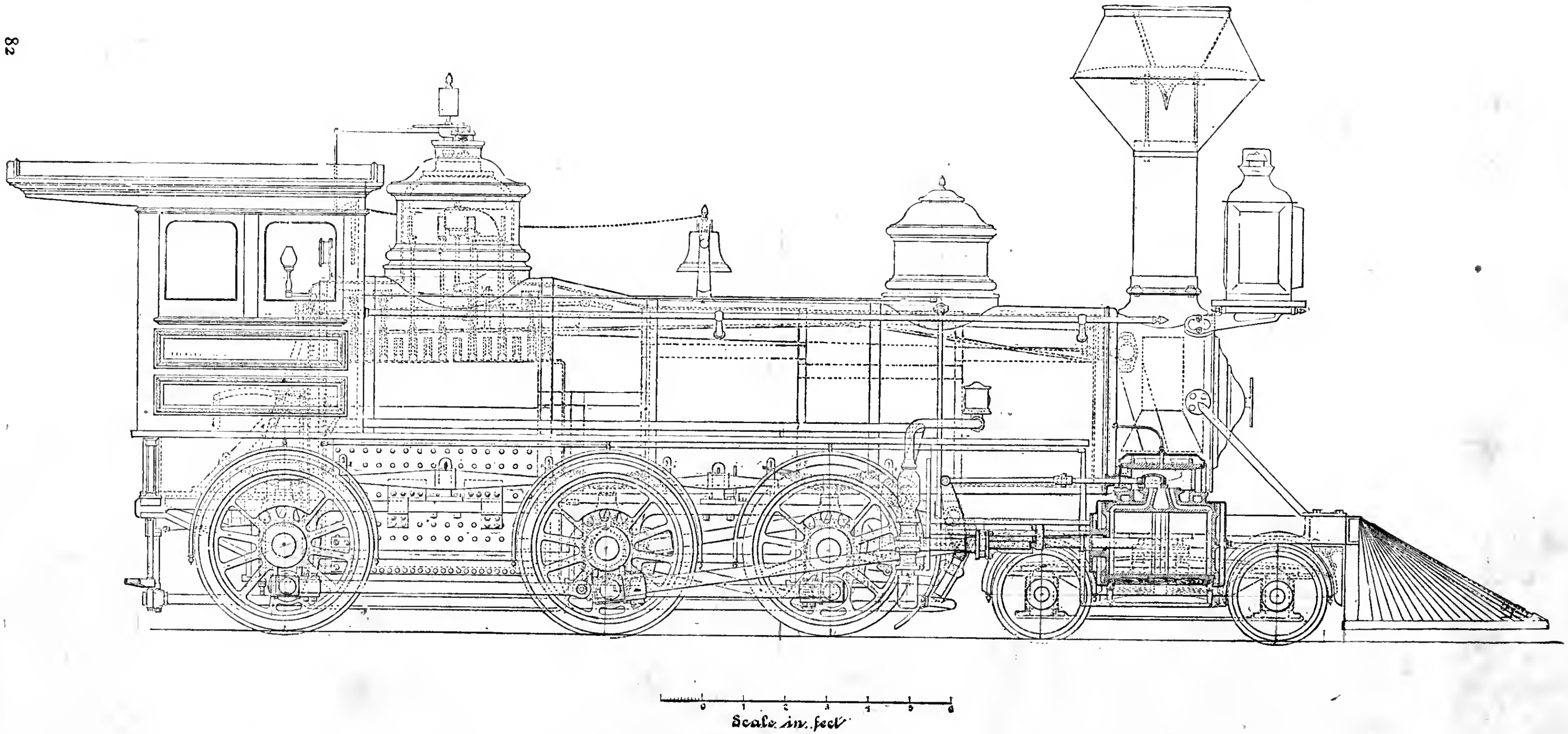
Station	Time	Min.
Jersey City	2.07 P.M.	
Elizabeth	2.21¾	14¾
Bound Brook	2.40½	18¾
		33½
Weston	2.45	4½
Vanaken	2.50½	5½
Skillman	2.55	4½
Hopewell	2.58	3
Pennington	3.02¾	4¾
Trenton Junc.	3.07½	4¾
Yardley	3.09¾	2¼
Woodburne	3.14¾	5
Langhorne	3.17	2¼
Willett	3.19½	2½
Somerton	3.22½	3
Bethayres	3.26	3½
Jenkintown	3.30¾	4¾
Tabor Junc.	3.35½	4¾
Wayne Junc.	3.38	2½
Ninth and Green	3.47	9
		100

1 hour and 40 minutes; 5 cars.

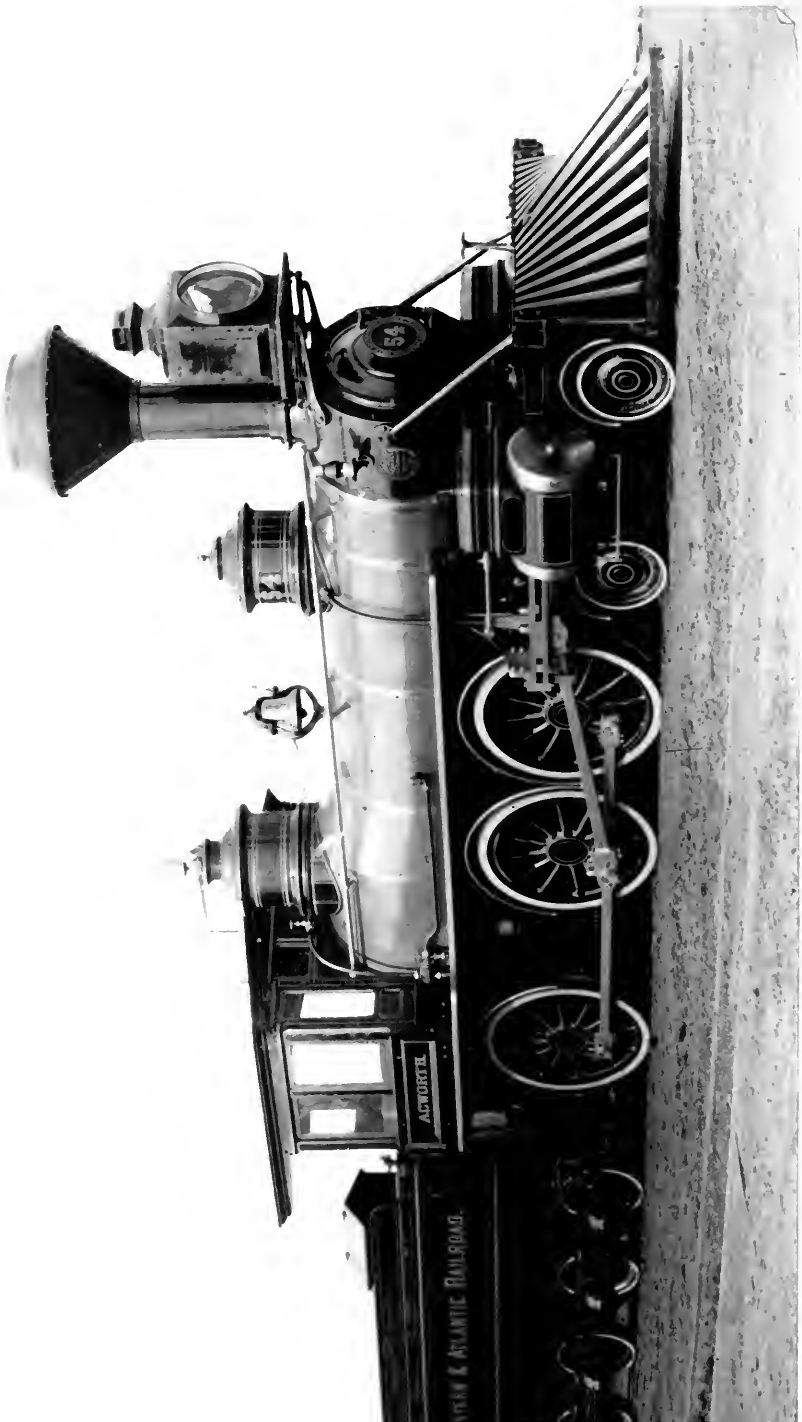
The fast passenger locomotive shown by the photograph on page 78 was constructed with a wide fire-box (7′ wide on the grate) adapted to anthracite coal. Where bituminous coal is used, the design could be modified to give a narrower fire-box.

The 4-wheeled truck under cylinders can be made with or without swinging bolster as preferred.

For further description of this type, see page 53 of the sketch.



"TEN-WHEELED" FREIGHT AND MIXED TRAFFIC LOCOMOTIVE.


54
ACWORTH
WESTERN & ATLANTIC RAILROAD.

FREIGHT AND MIXED TRAFFIC LOCOMOTIVES, "TEN-WHEELED" TYPE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Engraving and Photograph on pages 82 and 84.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF FOUR SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
									On a Level.	On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
10-26 D	16 × 24	51 to 56	12 6	22 8		2000	72,000	54,000	1565	685	405	280	205	160	125
10-28 D	17 × 24	51 to 56	12 10	23		2200	76,000	57,000	1650	725	425	295	215	170	135
10-30 D	18 × 24	51 to 56	13 1	23 3		2400	80,000	61,000	1770	775	455	315	230	180	145
10-32 D	19 × 24	54 to 60	13 6	23 8		2600	84,000	64,000	1855	810	480	330	240	190	155

The total wheel-base of engine, with 8-wheeled tender attached, varies from 43′ 9″ for Class 10-26 D to 44′ 9″ for Class 10-32 D. Where brakes are placed on all tender-wheels the wheel-base will be 1′ longer. From 18″ to 2′ should be added to these figures for clearance of flanges of extreme wheels. to give the minimum length of turn-table admissible.

Where anthracite coal is used as the fuel a different form of fire-box is required, similar to that shown in engraving on page 65. This lengthens the boiler and increases the total weight of the engine and the weight on the driving-wheels from 5000 to 6000 pounds.

The front and back driving-wheels can be flanged, the main pair plain, and the truck made with swinging bolster; or the main and back driving-wheels can be flanged and the front pair plain. In the latter case the truck should be without the swinging bolster.

A straight-top boiler, with dome in the middle, is made for locomotives of this pattern, when preferred to the wagon-top form of boiler.

PERFORMANCE OF "TEN-WHEELED" LOCOMOTIVES.

CLASS 10-26 D ON GRADES OF 32 TO 56 FEET PER MILE.

DELAWARE WESTERN RAILROAD COMPANY.

WILMINGTON, DEL., November 13, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Gentlemen,—Answering your favor of the 10th inst., I will say that the total weight of Engine No. 4 is 72,300 lbs.; 54,200 on driving-wheels, 18,100 on truck.

We have taken a train weighing 1,030,350 lbs. (460 gross tons) from Landenberg to Southwood, 3 miles; grades ranging from 32′ to 56′ per mile, with 8° curves. The road between these points is very crooked, there being two or three reverse curves. Steam pressure was 125 lbs. Train was weighed accurately.

Truly yours,

(*Signed*) D. CONNELL,

Superintendent.

CLASS 10-26 D ON GRADE OF 52 1-8 FEET PER MILE.

CHRISTIANIA, NORWAY, August 1, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Mr. Pihl requests me to tell you that on the opening of the new line connecting Sweden with Norway, *via* Frederickshald, the new Baldwin locomotive "Washington" pulled the royal train across the frontier.

34 passenger cars	tons,	268.6
Luggage for 300 passengers @ 200 lbs.	"	22.3
Tons		290.9

Gradient, 1′ in 100′; curve, 1000′. The train was run at a speed of about 20 miles.

GERH. GADE.

CLASS 10-28 D ON GRADE OF 77 FEET PER MILE.

WESTERN MARYLAND RAILROAD.

UNION BRIDGE, MD., April 29, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Engine No. 7 hauled 14 heavy loads up a grade of 77′ to the mile, with two reverse curves, with 120 lbs. of steam, running 12 miles per hour; distance, 6 miles.

DAVID HOLTZ,

Master of Machinery.

CLASS 10-28 D, ANTHRACITE-BURNING, ON GRADE OF 150 FEET PER MILE.

On the Catasauqua and Fogelsville Railroad a locomotive of Class 10-28 D pulls 16 loaded cars, total weight of train 128 gross tons, up a grade of 150′ per mile combined with 12° curves.

CLASS 10-30 D ON GRADE OF 79 2-10 FEET PER MILE.

YOUGHIOGHENY RAILROAD.

IRWIN STATION, PA., April 24, 1879.

Dear Sir,—I have your favor of the 21st inst. at hand in reference to engine "Sewickley." Maximum load for this engine over Youghiogheny Railroad is 18 cars, 42,000 lbs. to the car. Maximum grade up which the coal is hauled is $79\frac{2}{10}'$ per mile. On this maximum grade we have a curve of 7° (819′ radius), 885′ in length. Our regular load for this engine is 15 cars in the different conditions of the rail, and on some days we haul 16 cars. Average weight of cars, 42,000 lbs., including car.

W. WILSON,

Superintendent.

CLASS 10-30 D ON GRADES OF 21 AND 62 FEET PER MILE.

(NOTE.—Cylinders 18″ x 24″, driving-wheels 55″ diameter.)

BUFFALO, NEW YORK, AND PHILADELPHIA RAILWAY COMPANY.

GENERAL SUPERINTENDENT'S OFFICE, BUFFALO, April 21, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Below you will find a statement of what the 10-wheeled freight engines are doing daily and doing easily.

Going South. They are hauling 48 empty cars, about 386 gross tons, up a 62′ grade, on 4° curves.

Coming North. They are hauling 40 loaded cars, about 785 gross tons, on a 21′ ascending up grade, on 5° curves.

Cars will weigh 9 net tons, and lading 13 net tons.

Yours respectfully,

(*Signed*) GEO. S. GATCHELL,

General Superintendent.

CLASS 10-32 D ON GRADES OF 75 TO 101 FEET PER MILE.

(NOTE.—Cylinders 19″ x 24″, driving-wheels 55″ diameter.)

ST. LOUIS AND SAN FRANCISCO RAILWAY COMPANY.

OFFICE OF THE GENERAL MANAGER, ST. LOUIS, MO., July 14, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—The two new 10-wheeled freight locomotives bought from you in February last are performing very satisfactory service on our road. They are mainly running on our second division, where between Dixon and Lebanon the maximum grade adopted was 75′ per mile and maximum curve 6°. There are no reverse curves, properly speaking, but many of them are practically such, there being only 200′ of tangent between them. The grades, owing to settlement of embankments, are in some places 80′ to 90′ per mile for short distances, and the average grade of 75′ per mile occurs in many places for 2 miles or more. What is known as Hancock Hill is the most trying grade on the division. It is about 12,000′ long; 1000′ of the grade at Hancock Station is 50′ per mile, the balance 76′ per mile. There are several 6° curves with short tangents between them. On this division these locomotives have pulled trains of 22 cars of stock, weighing (car and freight) 36,000 lbs. each, and caboose, at an average speed of 14 miles per hour, and up Hancock Hill at 11 miles per hour.

At Rolla Hill on first division is a grade 6 miles long, of 72′ per mile for 5 miles, and 101′ per mile for balance. Locomotive No. 35 has hauled 22 cars of stock and caboose up this hill.

Respectfully yours,

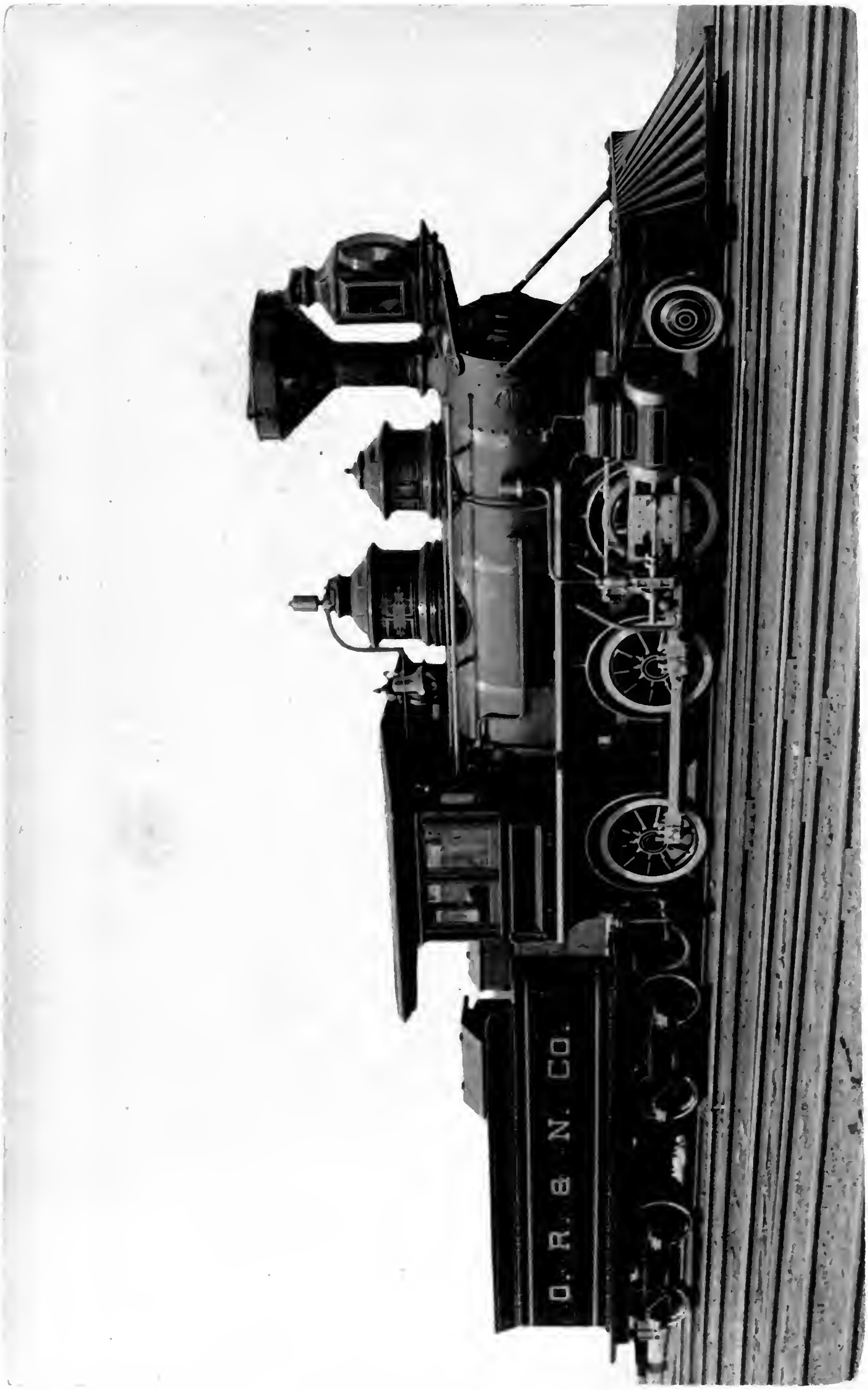
(*Signed*) C. W. ROGERS,

General Manager.

CLASS 10-30 D, ANTHRACITE-BURNING, ON GRADES OF 76 AND 126 FEET PER MILE.

On the Lehigh Valley Railroad the service performed by 10-wheeled anthracite-burning locomotives of Class 10-30 D is as follows:

	GROSS TONS OF TRAIN.	
	Grade, 126 Feet per Mile.	Grade, 76 Feet per Mile.
Maximum load	235	340
Usual "	169 to 200	221


O. R. & N. Co.

LIGHT FREIGHT LOCOMOTIVES, "MOGUL" TYPE,

FOR TRACKS LAID WITH RAILS WEIGHING 30 TO 40 POUNDS PER YARD.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Photograph on page 90.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF THREE SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-18 D	12 × 18	37 to 41	10	16		1200	40,000	33,000	930	405	240	160	120	95	75
8-20 D	13 × 18	37 to 41	10 4	16 6		1400	45,000	37,000	1075	470	280	190	140	110	85
8-22 D	14 × 18	37 to 41	11	17		1600	48,000	40,000	1160	510	300	205	155	120	95

Locomotives of above classes are in use on the Fort Dodge and Fort Ridgely Railroad, the Riverside Iron Works Railroad of Missouri (30 pounds iron rails), and the Oregon Railway and Navigation Company's Railroad of Oregon, all of 4′ 8½″ gauge.

The following minimum weights of rails are recommended as suitable: for Class 8-18 D, 30 pounds per yard; for Class 8-20 D, 35 pounds per yard; and for Class 8-22 D, 40 pounds per yard.

Total wheel-base of engine with 8-wheeled tender varies from 35′ for Class 8-18 D to 36′ for Class 8-22 D. Add 18″ to 2′ allowance for clearance of flanges, to get minimum length of turn-table.

PERFORMANCE OF CLASS 8-20 D ON 30 LB. RAILS.

RIVERSIDE IRON WORKS.

OFFICE, 1304 MAIN ST., WHEELING, W. VA., June 21, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Gentlemen,—Our road, 7¼ miles long, has been operated since about the 1st of May, and quite to our satisfaction. We have curves of 10° and grades of 3′ per 100′ in places (the longest about ½ mile), while on Y we have curves of 24°. Track is laid with 30 lb. rails, with 3168 ties per mile. Ties 6″ × 6″ × 8′. Our regular load for engine is 4 cars, weighing 19,000 lbs. each, loaded with 12 tons of 2300 lbs. = 27,600 lbs., or car and load 46,600 lbs. Engine will haul 5 cars by running for grades, but we consider it imprudent to load more than we can safely start and stop on heaviest grades. Have hauled 9 empty cars at one time. We make 4 round trips daily, allowing 45 to 50 minutes actual running time each way, and using rest of time switching, wooding, taking water, etc. If desired, we can make 5 round trips daily in 10 or 11 hours. The engine consumes daily 2½ cords of wood of rather inferior quality, and only cut about one month. Our syphon lifts tender full of water a distance of 16 feet in about 12 to 15 minutes, and we are highly pleased with the arrangement.

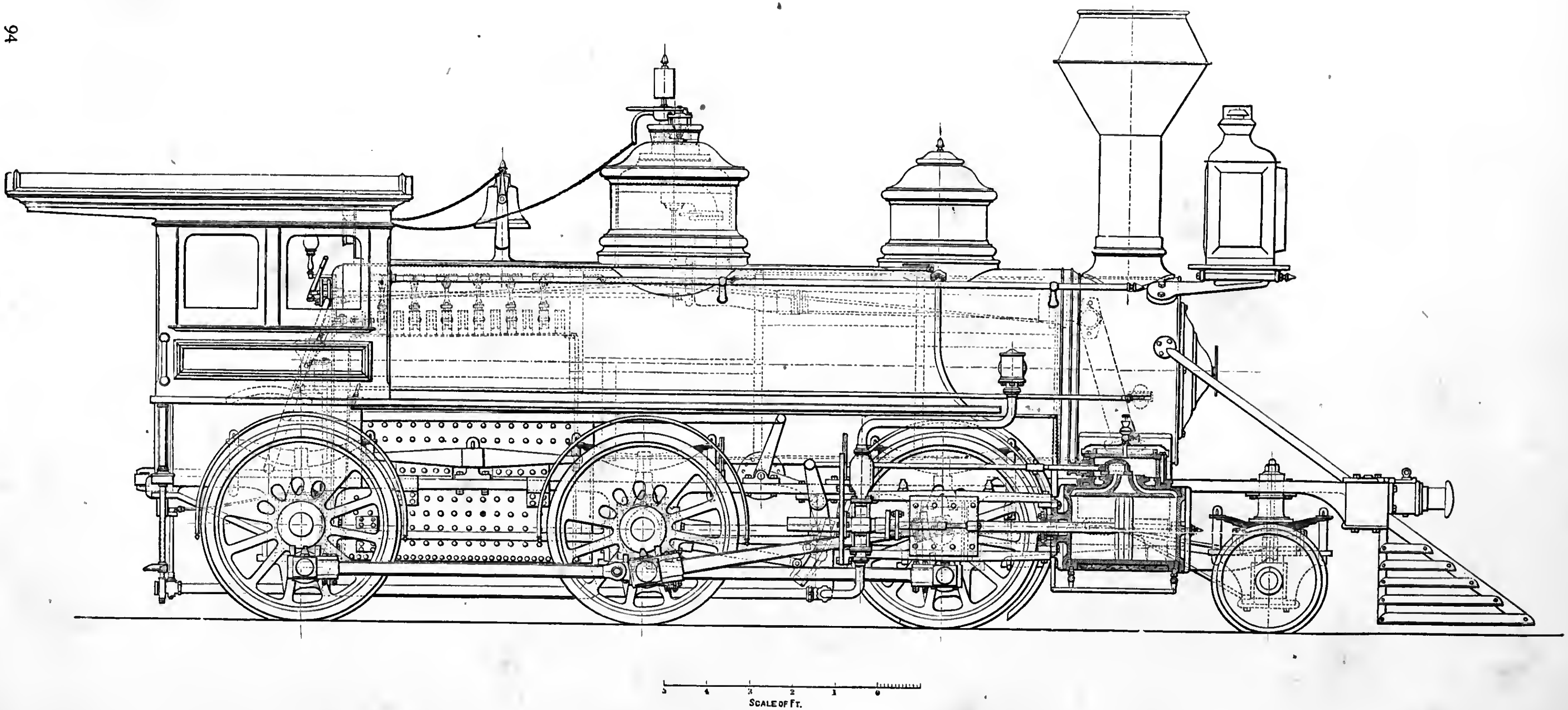
Our rails seem to bear the traffic quite as well as expected, although would recommend 35 lbs. instead of 30 lbs. We used the latter because of our own make, and we manufacture nothing heavier.

We think you can safely advise your friends to adopt the light wide gauge for slow speed in short branch lines rather than the narrow gauge.

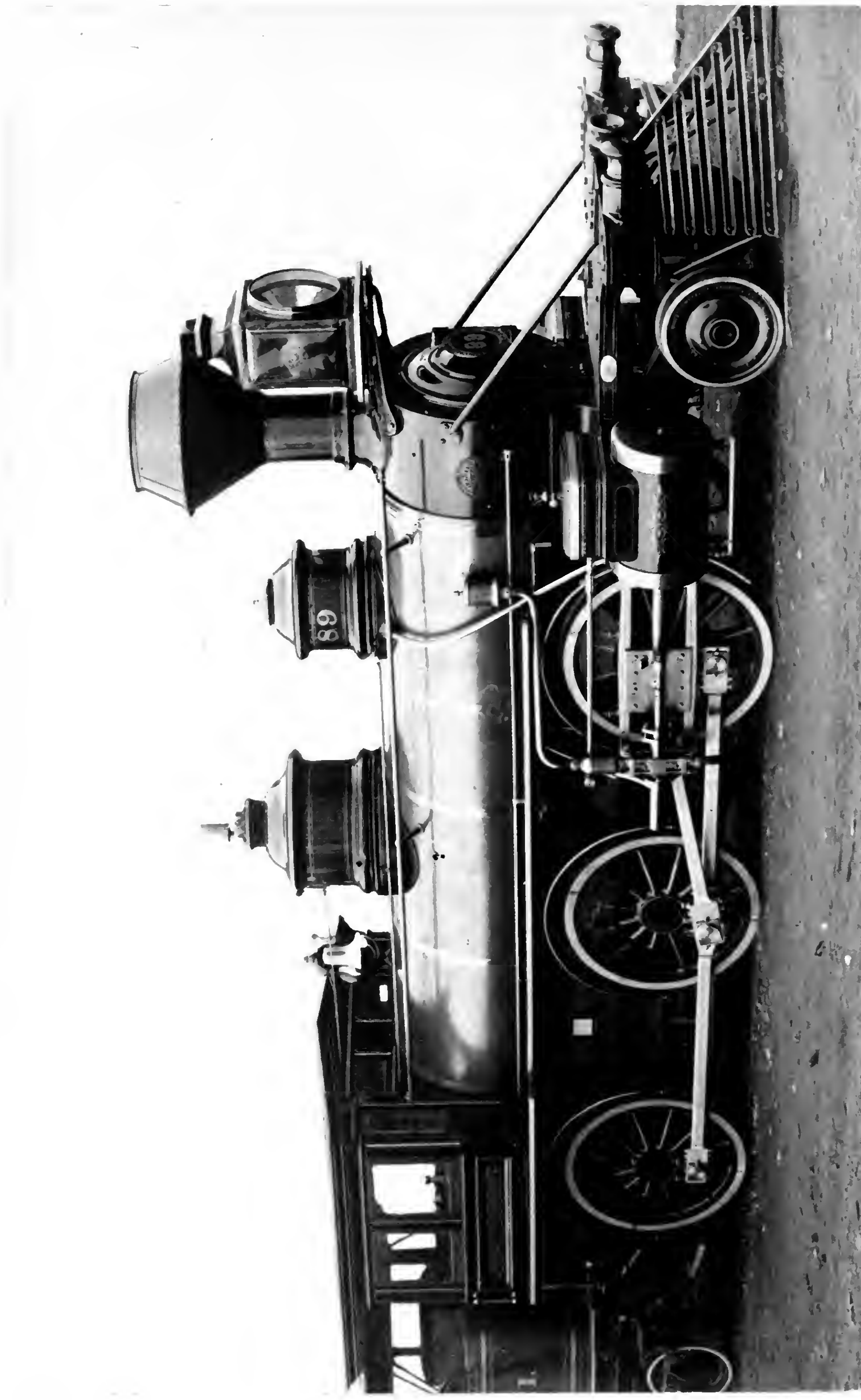
We are moving about 190 tons of 2300 lbs. daily, at a total cost for train service, track repairs, fuel, oil, waste, etc., of about 1½ cents per ton per mile. Our track repairs will become somewhat heavier after a while, although owing to hurried construction without ballast we now maintain a track force of 6 men and foreman. We pay connecting road ¾ of a cent per mile, loaded and empty, for car mileage, or ⅚ of a cent per ton of ore transported, and avoid all expense for car repairs, oiling, etc., and have investment in one engine only and no cost for transfer of load.

Yours truly,

(*Signed*) F. J. HEARNE.



FREIGHT LOCOMOTIVE, "MOGUL" TYPE.



FREIGHT LOCOMOTIVES, "MOGUL" TYPE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR BITUMINOUS COAL.

General Design shown by Engraving and Photograph on pages 94 and 96.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF FOUR SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-26 D	16 × 24	45 to 51	14 2	21 6		2000	71,000	60,000	1740	770	455	315	235	185	150
8-28 D	17 × 24	49 to 54	14 6	21 10		2200	75,000	63,000	1835	805	480	330	250	195	155
8-30 D	18 × 24	51 to 56	14 9	22 1		2400	78,000	66,000	1920	845	500	345	260	205	160
8-32 D	19 × 24	54 to 60	15 2	22 6		2600	82,000	69,000	2000	880	520	360	270	215	170

The front and back driving-wheels must have flanged tires in this type of locomotives; the middle or main driving-wheels have wide tires without flanges. The "pony truck" has a swinging bolster, and by means of a radius bar is made to radiate about a point located between itself and the front driving-axle.

The total wheel-base of engine with 8-wheeled tender varies from 42′ 4″ for Class 8-26 D to 43′ 4″ for Class 8-32 D. When brakes are placed on all tender-wheels the wheel-base will be 1′ longer. To get minimum length of turn-table admissible, add from 18″ to 2′ for clearance of flanges.

When anthracite coal is used as fuel the form of fire-box is similar to that shown in engraving on page 65. This lengthens the boiler and increases the total weight of engine and the weight on the driving-wheels from 4000 to 5000 pounds.

The several classes of "Mogul" locomotives above described can be built with tanks on boilers instead of separate tenders, if desired, making an excellent type of engine for heavy switching service.

The arrangement of driving-wheels in locomotives of the "Mogul" type can, if desired, be modified, by grouping them closely together. The driving-wheel-base can thus be reduced to 10′ or 10′ 6″, and the total wheel-base to 17′ or 18′. This plan, however, necessitates placing the fire-box over the back driving-axle, and therefore allows of only a shallow fire-box.

PERFORMANCE OF "MOGUL" LOCOMOTIVES.

CLASS 8-26 D ON GRADE OF 83 FEET PER MILE.

OFFICE OF THE SHARPSVILLE RAILROAD COMPANY.

SHARPSVILLE, PA., July 16, 1877.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Gentlemen,—The traffic of our road consists in bringing coal *down grade* from our mines (of which we have eleven, supplying a business of from 800 to 1500 tons *per diem*), and hauling our empties *up grade* to the mines.

We have a gradient, rising towards the mines, of 83′ per mile with a 2° curve in it. This I account equivalent to a gradient of 87′ per mile on a straight line.

On this gradient, equal to 87′ per mile, the "Oakland," on July 3, 1877, started from a standstill 45 empty 8-wheeled cars, weighing 669,500 lbs., or 334.75 net tons, and, without slipping her driving-wheels, took the train up and beyond the gradient, something more than half a mile, gaining speed and steam as she went. She had 130 lbs. of steam at the start; we had to open the furnace-door to prevent undue increase of pressure.

On July 12th, the same engine, standing *below* the train and *pushing* up the hill, and getting no advantage from the starting of one car after another, as she might have done had she been hauling the train, started from a standstill, on same gradient, 18 *loaded* 8-wheeled cars, weighing 329.36 net tons, and, without slipping her driving-wheels, took them up and over the gradient, gaining speed and steam as she went. Steam 130 lbs. at start.

On the 29th of May, 1877, same engine, *pushing*, started 28 *loaded* 8-wheeled cars, weighing 512.28 net tons, on a piece of track where the engine and tender and 23 cars were on a gradient of 40.5′, and 5 cars on a gradient of 54′ per mile, and, without slipping her driving-wheels, took them up over a gradient of 44½′ per mile for ½ a mile or more, gaining speed as she went. She made steam much more rapidly than she could use it, but by watching the steam-gauge, and varying the weight on the escape-valve according to the indications of the gauge, an uniform pressure of 125 lbs. was maintained throughout this trial.

The "Oakland" does work equivalent to the performance here recorded every working day in the year.

Yours, very truly,

J. M. GOODWIN,
Engineer Sharpsville Railroad.

CLASS 8-26 D ON GRADE OF 53 FEET PER MILE.

WESTERN RAILROAD OF ALABAMA.

OFFICE OF MASTER MECHANIC, MONTGOMERY, ALA., January 30, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Mogul engine "Marchioness" hauls 21 cars on the same schedule that our other engines (Class 8-22 C) haul 15; and 25 cars on irregular trains.

ROBERT KING,
Master Mechanic.

CLASS 8-28 D ON GRADES OF 40 TO 47 FEET PER MILE.

On the Terre Haute and Indianapolis Railroad locomotives of Class 8-28 D (cylinders 17″ × 24″, driving-wheels 55″ diameter) have hauled, each, 28 loaded cars from Terre Haute to Indianapolis, and 54 cars (45 empty and 9 loaded) from Indianapolis to Terre Haute. The maximum grades range from 40′ to 47′ per mile.

CLASS 8-28 D ON GRADE OF 70 FEET PER MILE, COMBINED WITH 6 DEGREE CURVE.

(NOTE.—The locomotives referred to are 17″ x 24″ cylinders, driving-wheels 54″ diameter.)

EAST TENNESSEE, VIRGINIA AND GEORGIA RAILROAD.

KNOXVILLE, TENN., December 2, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Dear Sirs,—The Moguls have sometimes pulled 18 loaded cars over the road, but these cars and loads have not weighed 46,000 lbs. each. They will pull 17 cars with such loads, but not more. It is almost practically impossible to get in any day the 17 cars loaded with 13 tons each, in the varying conditions of traffic; but the 18 cars, as they come, will be equivalent to 17 cars so loaded. When the cars are heavily loaded 17 is all they will take.

Very truly yours,

JOHN F. O'BRIEN,
Superintendent.

CLASS 8-28 D ON GRADE OF 85 FEET PER MILE, COMBINED WITH 9 AND 10 DEGREE CURVES.

EASTERN KENTUCKY RAILWAY COMPANY.

MACHINE SHOP, HUNNEWELL, KY., May 31, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Yours of the 27th inst. came duly to hand, and in reply I would say, that it was the Mogul locomotive (17″ × 24″ cylinders, driving-wheels 54″ diameter), constructed by your works in 1873, with which we made the experiment stated in my letter to the Committee of the Master Mechanics' Association. The 8-wheeled engine, in comparison with which the test was made, had cylinders 16½″ × 24″, and 4 driving-wheels 54″ diameter.

The test was made for our own information, to see whether it was not cheaper to run that class (the Mogul) than the 8-wheeled engine, and the result proved to us practically that it was.

The Mogul hauled up our 85′ grade, on which there are two 9° curves and one of 10°, 37 loaded cars, each carrying 5 tons (of 2240 lbs.); total lading, 185 tons; weight of cars when empty, 3½ tons each; total weight of train hauled, including total weight of cars, 314½ tons.

The 8-wheeled engine hauled 205 tons, or 24 cars. Pressure on the Mogul at the start was 135 lbs.; when at the top of the grade, 120 lbs.

On the curves the engine was worked in the second notch; on the remainder of the grade, in the third.

The Road Master says that it is all a mistake about the Mogul being hard on the track and curves. He does not see any difference in this respect between this class and the 8-wheeled engines.

The great item in respect to economy is, it costs us as much for train hands to run the 8-wheeled engine as it does to run the Mogul, and we get one-third more coal and ore over our road with the Mogul at one trip.

Yours, very truly,

(*Signed*) D. L. WEAVER,
Master Mechanic.

CLASS 8-30 D ON GRADES OF 53 TO 60 FEET PER MILE.

FLINT AND PERE MARQUETTE RAILWAY.

SUPERINTENDENT'S OFFICE, EAST SAGINAW, MICH., July 3, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—Your favor of the 30th ult. is at hand. In answer, Mogul Engine No. 45 (cylinders 18″ × 24″, driving-wheels 50″ diameter) has pulled 28 loaded cars over the road between Ludington and Lake. Forty miles of this portion of the road is up grade. For 9 miles of the above the grade varies from 53′ to 60′ per mile. The longest pull of 53′ grade is about 1½ miles; with then a short space of

about 25′ grade; then up to 60′ for about ¾ of a mile; then a change to 56′, 54′, and 53′ grades, with reverse curves of 2° and 3°.

The other engine, No. 46, is fully as good and is doing service equal to the above daily.

Yours truly,

(*Signed*) SANFORD KEELER.

CLASS 8-30 D ON GRADES OF 53 TO 75 FEET PER MILE.

MISSOURI, KANSAS AND TEXAS RAILWAY.

OFFICE OF SUPERINTENDENT OF MACHINERY, SEDALIA, MO., April 13, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—Engine 89, Mogul pattern (18″ × 24″ cylinders, 50″ driving-wheels), purchased of you, has developed her average maximum power on the district to which she is assigned, and a statement having been promised, is herewith made.

With a steam pressure of 135 lbs. (road standard) Engine 89 has hauled a freight train weighing 600 tons (of 2000 lbs.), exclusive of engine, from Moberly to Hannibal over grades of 53′ and 60′. Curves of 1° 3′ occur in combination with the 60′ grade.

Between Boonville and Sedalia the same engine, and with same steam pressure, has hauled a freight train weighing $479\frac{13}{20}$ tons, exclusive of engine, over numerous grades of 60′, 65′, 70′, to 75′ per mile, and reverse curves of 1° to 3° on heaviest. Train was weighed at terminal station for the purpose of this statement.

Neither of the performances above noted were made under specially favorable circumstances, but are intended as rating the daily duty of the engine hereafter.

On a trip of 143 miles Engine 89 consumes about 30 per cent. more fuel and develops 40 per cent. more power than ordinary American pattern engines with 17″ × 24″ cylinders, and 60″ driving-wheels.

Respectfully,

(*Signed*) G. W. CUSHING,
Superintendent of Machinery.

CLASS 8-30 D ON GRADE OF 53 FEET PER MILE.

CHILLAN AND TALCUHUANA RAILWAY.

CONCEPCION, CHILI, November 7, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

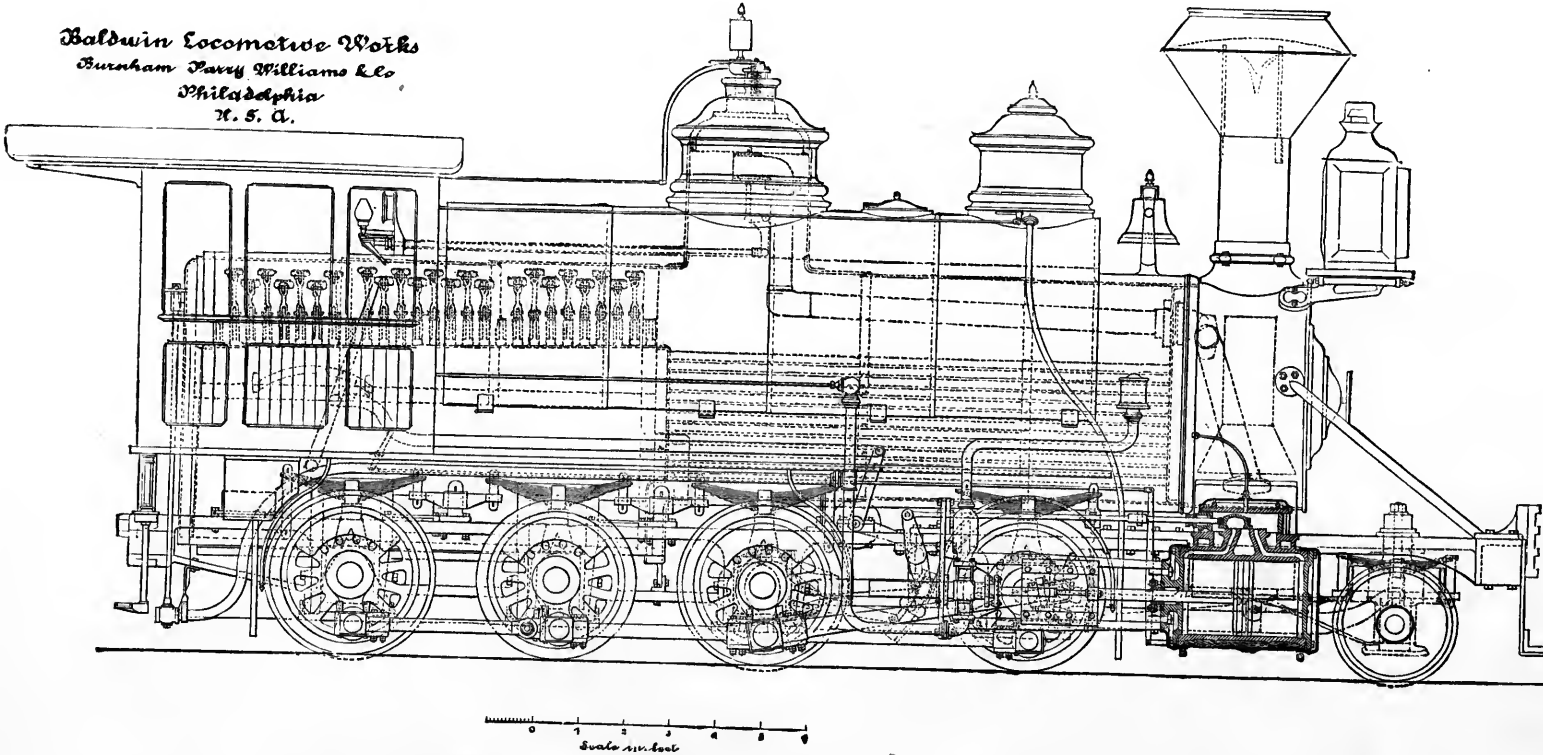
Gentlemen,—The heaviest grades of this line are one per cent., but they are not more than a mile long, so that a good run takes the engine over them.

The 18″ × 24″ Mogul freight engines each handle 40 to 45 cars easily on them, and with a man who can take advantage of the road more can be taken.

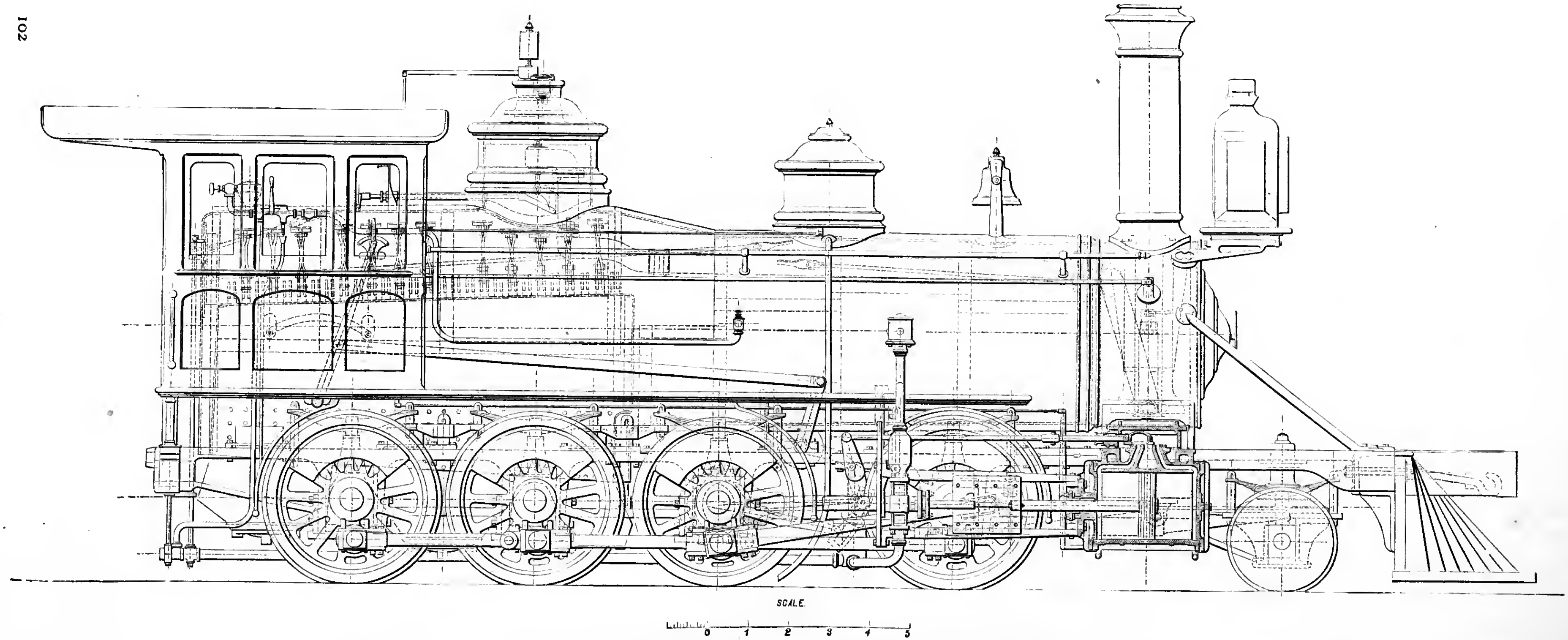
We limit the load with these engines to 40 cars for nearly one-half the run where we have two or three such grades, and for the rest of the distance they frequently bring from 50 to 60 cars. Average weight, 19 tons.

Yours, etc.,

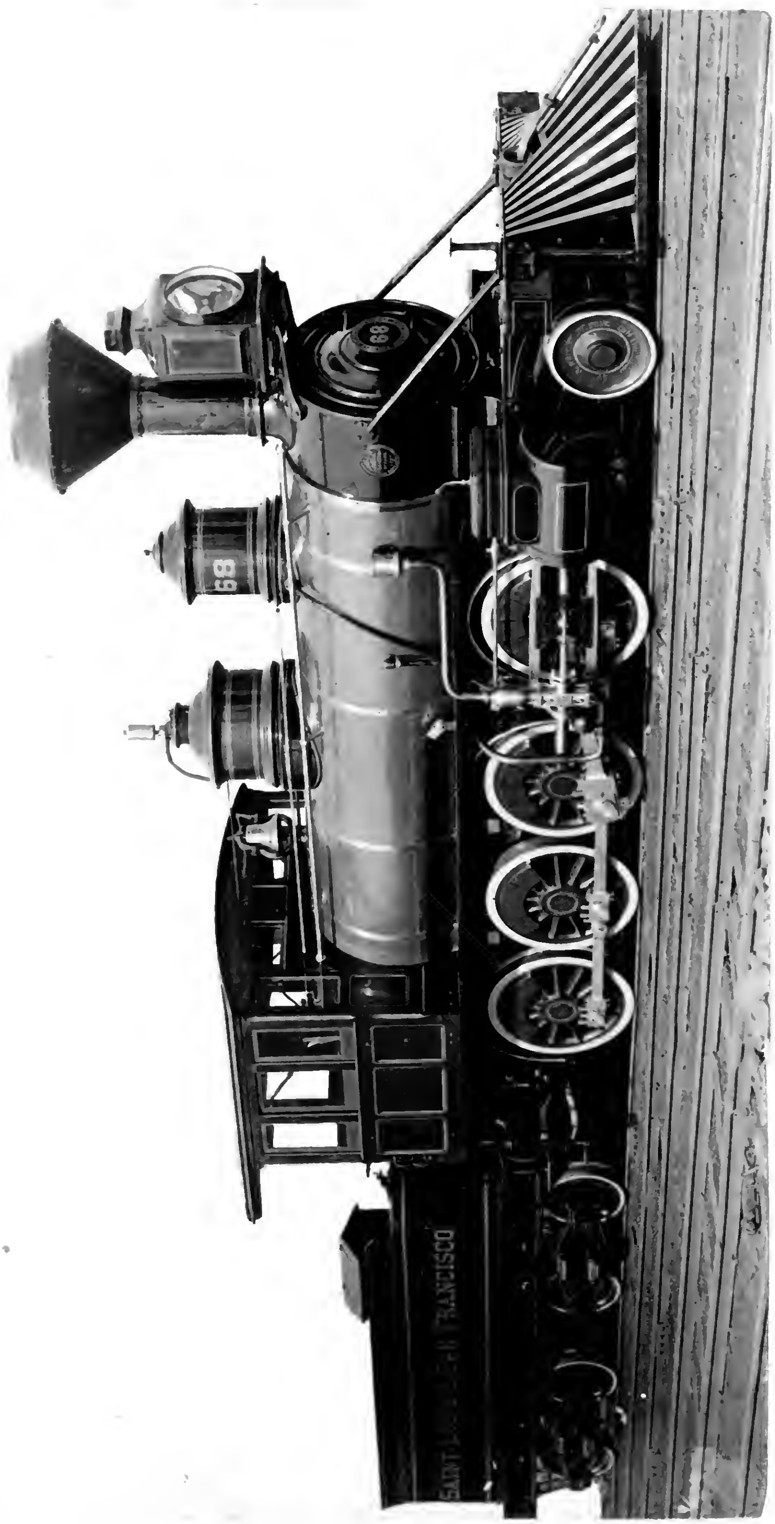
JOHN E. MARTIN,
Locomotive Superintendent.



FREIGHT LOCOMOTIVE, "CONSOLIDATION" TYPE, WITH TANK ON BOILER.



FREIGHT LOCOMOTIVE, "CONSOLIDATION" TYPE.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FREIGHT LOCOMOTIVES, "CONSOLIDATION" TYPE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, ANTHRACITE OR BITUMINOUS COAL.

General Design shown by Engraving and Photograph on pages 102 and 104.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF TWO SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
									On a Level.	On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.		26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
10-34 E	20 × 24	48 to 50	14 9	22 10		2600	102,000	88,000	2560	1130	670	465	350	275	220
10-36 E	21 × 24 or 20 × 26	48 to 50	14 9	22 10		2800	108,000	94,000	2740	1205	720	495	370	290	235

This type of locomotive is built with two pairs of flanged driving-wheels, either the front and rear or the main and rear pairs. The other two pairs of coupled wheels have tires without flanges. The pony truck has a swinging bolster and radius bar, the same as in the "Mogul" type.

The form of fire-box is adapted to either bituminous or anthracite coal as fuel.

The total wheel-base of engine with 8-wheeled tender is 47′ 10″ when brakes are on all tender-wheels. A turn-table of about 50′ as a minimum is therefore required.

PERFORMANCE OF "CONSOLIDATION" LOCOMOTIVES.

ECONOMY IN FUEL AND WORKING EXPENSES OF "CONSOLIDATION" LOCOMOTIVES.

PENNSYLVANIA RAILROAD COMPANY, PHILADELPHIA AND ERIE RAILROAD DIVISION.

WILLIAMSPORT, PA., September 11, 1876.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—In conversation with you some time since, I promised to send you the performance of the Class I engines on this division of the Pennsylvania Railroad; in compliance with which promise, I inclose three statements showing the work of these engines from January 1 to July 1, 1876.

Two of these statements ("A" and "B") are copies from a letter from me to Mr. James Dredge, one of the editors of *London Engineering;* the third, "C," containing the same information regarding the Class I engines in use on the Susquehanna Division of the Northern Central Railway, from May 1 to September 1, 1876.

The large amount of work done by these engines in a short time shows that they do not need the constant repairs which some people assert such engines would require, it being a commonly received opinion that although Consolidation engines may haul more cars in a single train than lighter engines, they could not do so much work in a given time. These figures leave no ground for such fears. The engines are hauling trains on the same schedule as our ordinary 10-wheel engines work on, and you understand, of course, that owing to fluctuations in traffic we often have to run engines over our line empty, or with half trains, so that the average train is very much below the usual load. The maximum load on a level division, with which we expect the men to make time, may be taken at 90 cars, though on one day we hauled 110 cars into Harrisburg.

Yours respectfully,

HOWARD FRY,

Superintendent of Motive Power.

(NOTE.—Class I, Consolidation pattern, cylinders 20″ x 24″, 8 driving-wheels. Class D, 10-wheel pattern, cylinders 18″ x 22″, 6 driving-wheels.)

STATEMENT "A."

Average lbs. of fuel per car mile. Engines of Classes I and D compared.

DIVISION.	CLASS I.	CLASS D.
Western (between Erie and Langdon's, heaviest grade) . . .	3.8	4.7
Eastern (between Renovo and Jersey Shore, heaviest grade) . .	2.7	3.5
Susquehanna	2.5	3.4

STATEMENT "B."

Performance of I engines on Philadelphia and Erie Railroad Division.

ENGINE.	DIVISION.	ENGINE MILEAGE:	ACTUAL MILEAGE OF CARS.	Actual No. of Cars in Train Hauled each Engine Mile.
1004	Western.	22.924	887.163	38.7
1011	Eastern.	24.402	1.730.310	69.4

STATEMENT "C."

Performance of I engines on Susquehanna Division, Northern Central Railway.

ENGINE.	DIVISION.	ENGINE MILEAGE.	ACTUAL MILEAGE OF CARS.	Actual No. of Cars in Train Hauled each Engine Mile.
13	Susquehanna.	10.592	868.646	82.0
14	"	9.248	744.973	80.6

PENNSYLVANIA RAILROAD COMPANY, PHILADFLPHIA AND ERIE RAILROAD DIVISION.

WILLIAMSPORT, PA., January 29, 1877.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Dear Sirs,—We send you herewith a sketch, as requested, showing the performance of the two Northern Central Consolidation engines which are working on the Susquehanna Division. These engines were built at your works and have been under our charge about eight months; they are numbered 13 and 14, and belong to the class of engines known on the Pennsylvania Railroad as Class I.

Underneath their performance is shown that of the best 10-wheel engine, known on the Pennsylvania Railroad as Class D.

No particular effort was made with either of them to get excessive mileage out of them, and therefore we show the performance of another Class I engine on the Eastern Division of the Philadelphia and Erie Railroad, to illustrate the amount of work which can be done when necessary. You will see in the latter case that 41,000 miles were obtained in about 11 months' work, the engine having been in shop through accident for one month.

The statement, I think, explains itself, and shows that had the work done by Engines 13 and 14 been performed by a 10-wheel engine, it would have cost 11.7 cents more in one case and 8 cents more in the other than when done by Consolidation engines.

We believe these figures will be materially altered by further experience, owing to the cost of the 10-wheel engine being exceptionally low. You will understand, of course, that the trains hauled by each engine are not maximum trains, but are the average trains hauled during the year. Had maximum trains been hauled the result would have been still more favorable to the Consolidation engines.

Yours truly,

HOWARD FRY,

Superintendent of Motive Power.

Statement of performance of engines of Classes D and I, 1876.

ENGINES.		Division.	Mileage.	Average Train.	Lbs. Fuel per Car Mile.	EXPENSE IN CENTS PER ENGINE MILE.									REMARKS.
Number.	Class.					Repairs.	Fuel.	Stores.	Train Hands.	Total.	Reduced to Basis of I.	Reduced to Basis of D.	Saved by Use of I.	Lost by Use of D.	
13	I	Susq.	19606	64.8	2.7	7.6	13.9	.6	14.5	36.6		48.3	11.7		8 months' work.
14	I	"	19466	64.5	2.6	6.9	18.0	.7	14.5	40.1		48.1	8.0		8 " "
	D			34.9	3.5	1.2	11.3	.5	13.0	26.0	20.7			5.3	Average D engine.
1011	I	East'n.	41796	55.5	2.6	4.1	11.1	.5	17.1	32.8		38.3	5.5		12 months' work.

PENNSYLVANIA RAILROAD COMPANY, PHILADELPHIA AND ERIE RAILROAD DIVISION.

WILLIAMSPORT, PA., December 27, 1877.

J. F. ROBINSON, ESQ.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Dear Sir,—I append the arriving and leaving time of the train attached to N. C. Engine No. 41, on which you rode between Sunbury and Harrisburg, October 27th last, together with weight of train and radii of some of the curves on the line.

The train consisted of 87 cars of oil and 13 cars of grain.

Weight of grain	312,000 lbs.
Gallons of oil, 327,267; weight	2,454,502½ "
	2,766,502½ lbs.
Light weight of cars	2,014,700 "
Weight of engine, tender, and fuel	151,000 "
	4,932,202½ lbs.

Equal to 2201 tons of 2240 lbs. each. Length of train, 3127′ (excluding engine and tender).

The time of arriving and leaving of train was as follows:

DISTANCES FROM BALTIMORE. MILES.		ARRIVING.	LEAVING.
138	Sunbury		10.20
133	Selin's Grove	10	52
126½	Treverton Junction	11.25	12.20
121½	Georgetown	12	44
120½	" Water Tank	12.49	12.52
111¼	Millersburg	1	30
105½	Halifax	1	53
99	Clark's Ferry	2	20
92½	Dauphin	2	41

The radii of the sharpest curves over which you passed were:

Above mile post 129 (below Selin's Grove)	1020′
" " 116 (2 miles north of Mahantango Station)	1300′
" " 114, Liverpool Station	1510′
" " 106½, Armstrong Creek	1080′
" " 97½	860′

To show you that the train figures given are not exceptional, I have added a statement showing the number of cars hauled by Engine No. 41 on eastward bound trains, in the month of October, between Sunbury and Harrisburg.

Yours truly,

(*Signed*) HOWARD FRY.

(NOTE.—The line between Sunbury and Harrisburg, which forms the Susquehanna Division of the Northern Central Railway, is practically level, with occasional slight declines toward the east.)

Statement of the number of loaded 8-wheel cars in each east bound train hauled by N. C. Engine No. 41, between Sunbury and Harrisburg, during the month of October, 1877:

October 2d, two trips of 90 each	180 cars.
" 3d	90 "
" 5th	93 "
" 6th	77 "
" 7th	90 "
" 8th	86 "
" 9th	92 "
" 10th	90 "
" 11th	88 "
" 12th	90 "
" 13th	106 "
" 14th, two trips of 90 and 91 each	181 "
" 16th	91 "
" 17th	90 "
" 18th	91 "
" 19th	85 "
" 20th	90 "
" 21st	88 "
" 23d	88 "
" 24th	91 "
" 27th	100 "
" 28th	90 "
" 30th	90 "
" 31st	92 "
26 trips. Total	2349 cars.

Which gives an average of 90.3 cars per trip.

PENNSYLVANIA RAILROAD COMPANY, PHILADELPHIA AND ERIE RAILROAD DIVISION.

WILLIAMSPORT, PA., January 24, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO., PA.:

Gentlemen,—In order to show the consumption of fuel by the Consolidation locomotives as compared with other classes, I copy the following figures from our October report:

SUSQUEHANNA DIVISION, N. C. R. W.

Engine No.	CLASS.	Car Mileage.	Lbs. Fuel per Car Mile.	Average Train.
4	10-wheeled, D.	56,193	2.2	38.5 cars.
13	Consolidation, I.	188,000	1.8	67. "
14	" "	175,152	1.8	64.7 "
40	" "	204,861	1.7	65.8 "
41	" "	192,009	1.8	67.8 "

It is only occasionally that a 10-wheel engine runs on the Susquehanna Division. They often are as low as 2 lbs. per car mile. In all these figures loaded car mileage is meant: 5 empties reckoned as 3 loaded. The small trains are caused by running west so frequently without trains.

(*Signed*) HOWARD FRY.

CLASS 10-34 E ON GRADE OF 96 FEET PER MILE.

OFFICE OF THE DOM PEDRO II. RAILWAY.

RIO DE JANEIRO, May 25, 1871.

MESSRS. M. BAIRD & CO.:

Gentlemen,—The large engines last sent us give satisfaction, pulling 22 cars up the Sierra (grade 1′ in 55′) where the old ones took only 16 cars. The 22 cars weigh with their cargo 320 gross tons.

WILLIAM S. ELLISON,
Chief Engineer.

CLASS 10-34 E ON GRADES OF 116 AND 145 FEET PER MILE.

PENNSYLVANIA RAILROAD, TYRONE DIVISION.

TYRONE, June 5, 1870.

MESSRS. M. BAIRD & CO.:

Gentlemen,—Engine No. 1111 was first run up the mountain on Monday, May 9th. It was thought advisable to make the trip without attaching a train, so that its ability to traverse the sharpest curves might be tested. It was found that upon curves of 574′ radius and less the truck wheel on the inner rail was lifted up clear of the rail an inch or more for distances varying from 10′ to 50′, caused by the truck wheel on the outside rail of the curve binding against that rail, plainly indicating that the truck had not sufficient swing for such sharp curves. Your engineer on returning to Tyrone cut out the hangers enough to give 4″ play on either side, and this proved adequate for the sharpest curve (16° 40′), except in one or two spots where the curve was somewhat out of adjustment, when the wheel again lifted very slightly.

The arrangement of this truck seems to be admirably adapted to enable such a long engine to pass freely around curves, and the only limit I see to its application is the one that the rigid wheel base would not traverse, provided only that the truck was given a swing great enough to conform to the maximum curvature.

The next day, Tuesday the 10th, the engine was again tried with a light train to bring it fairly down to its work, when the performance was very satisfactory.

On Wednesday, May 11th, the trip was made on both sides of the mountain with the following result, viz.:

On the maximum grade of 145′ (south side), with 110 lbs. pressure, and speed 6 minutes to the mile, 26 empty cars; weight, 197 tons.

On the maximum grade of 116′ (north side), with 110 lbs. pressure, and speed 6 minutes to the mile, 13 loaded cars; weight, 234½ tons.

Second trip, 16 loaded cars; weight, 301 tons.

On this trip the pressure was 120 lbs. and the speed 7½ minutes to the mile.

In regard to fuel used it was impossible to form a very correct idea of the quantity, from the limited extent of the trial and the engine being new, etc., etc. It was therefore not attempted.

The engines we use on the mountain are rated at 15 empty cars, or about 120 tons, on the 145′ grade, and 10 loaded cars, or about 190 tons, on the 116′ grade. This is a fair load for them, and would compare with the performance of the No. 1111.

The trial for many reasons can only be taken as a close approximation. To determine accurately the best result would, in my judgment, require a much longer period. I am, however, led to believe that 200 tons, or 25 empty cars, on the south side, and 15 loaded cars, say 285 tons, on the north side of the mountain, would be a fair statement of the capacity of engines of this class on our road.

Yours very respectfully,

(*Signed*) GEO. C. WILKINS,
Superintendent.

CLASS 10-34 E ON GRADE OF 96 FEET PER MILE AND CURVE OF 400 FEET RADIUS.

LEHIGH AND SUSQUEHANNA DIVISION, CENTRAL RAILROAD OF NEW JERSEY.

ASHLEY, PA., September 20, 1871.

MESSRS. M. BAIRD & CO.:

Gentlemen,—In reply to your communication soliciting facts relative to the performance of the Consolidation class of engines, I would submit the following:

We have 5 of these engines in use. Two have been in service about four years, and the remaining 3 about three years. During this time they have been doing the heaviest kind of work.

Traversing Curves, etc.—There are few roads in this country with sharper curves or more of them in a given number of miles than ours. We have curves on the main line of about 400′ radius; consequently, the curving qualities of these engines are severely tested.

Although these engines are very heavy, the weight is so evenly distributed throughout their whole length that we consider it perfectly safe to run them at their maximum speed over all our bridges, and for the same reason we find them easy on the rail or road-bed.

Speed.—They will haul on a level track, with perfect ease, 1600 tons, at a speed of from 10 to 15 miles per hour, and they have been run at 20 miles per hour.

Steaming.—They are unsurpassed for their steaming qualities, and have never experienced a failure in this respect.

Tractive Power on Heavy Grades.—On the northern slope of the mountain we have 13 miles of heavy grades. From Ashley to Laurel Run (8 miles) the grade is 96′ per mile, and from Laurel Run to Solomon's Gap (5 miles) 64′ per mile; besides, the curvatures are frequent and very sharp. Forty loaded cars are hauled up this grade (weighing about 350 tons), and make the 13 miles within an hour.

The engines are constantly ascending and descending this grade (summer and winter) with no other appliance to check and control their speed than the ordinary double brake.

Our experience with these engines is that they are economical both in the consumption of fuel and cost of repairs.

(*Signed*) L. C. BRASTOW,
Superintendent of Machinery.

CLASS 10-34 E ON GRADE OF 96 FEET PER MILE AND 10 AND 14 DEGREE CURVES.

Lehigh Valley Railroad, Wyoming Division.

Wilkesbarre, December 12, 1871.

Messrs. M. Baird & Co.:

Gentlemen,—We have now in service 10 locomotives of the Consolidation class, constructed at your works. The first engine of this pattern was put in use on the Mahanoy grade in 1866, and the others have been added from time to time for working this and other inclines. Our experience with this style of engine has been thorough and extended, and we are satisfied as to their qualifications for working heavy grades and hauling maximum loads.

The result of our experience with these machines may be stated as follows:

Steaming.—Anthracite coal is used as fuel, and steam is generated freely and abundantly.

Speed.—These engines are run with their trains at speeds of from 10 to 20 miles per hour, and we have occasionally hauled passenger trains with them, particularly in winter, when they are of special service in clearing the track of snow.

Traversing Curves.—These engines are run on parts of the line having curves of 410′ radius, and they pass these curves without difficulty, and will also enter short curves in switches, and pass around any of our curves as readily as do our 8- or 10-wheeled engines.

Wear of Track.—We have no evidence that they wear the track more in hauling trains than other engines.

Loads Hauled.—We have on this division one long grade of 1′ in 55′, or 96′ per mile, for 12 miles in length, with curves of 573′ radius, several of them being reverse, and short tangents. The regular load of these engines on this grade is 33 loaded cars, which is equal to 264 gross tons of cars and lading. They will take this load to the summit in one hour, carrying 125 lbs. pressure of steam, and have occasionally exceeded this load and hauled up this grade 35 loaded cars, equal to 280 gross tons.

Descending Grades.—We use no appliance for retarding the engine in descending grades except the tender brake. With brakes on all eight of the tender wheels one of these engines is held without difficulty on the grade named.

Consumption of Fuel and Stores.—The quantity of fuel and stores used by these engines is less in proportion to load and mileage than that of any other engines we have in service.

As a practical evidence of the estimation in which this class of power is held by our company, I may refer to the order recently placed with you for 5 more of these engines for delivery in February and March.

Yours truly,

(*Signed*) A. MITCHELL,

Division Superintendent.

CLASS 10-34 E ON GRADE OF 45 FEET PER MILE.

MISSOURI PACIFIC RAILWAY COMPANY.

OFFICE SUPERINTENDENT MOTIVE POWER AND MACHINERY, ST. LOUIS, MO., January 30, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Gentlemen,—The four Consolidation locomotives, Nos. 107, 108, 109, and 110, came to hand in good order, and have been put together by your engineer.

We have made several changes in minor details (which we think are improvements) for convenience. The general design and finish, however, are very satisfactory, and the performance of Nos. 107 and 108, which have run a few trips, is fully up to our expectations. With careful firing they make abundance of steam, and haul *twice* as many cars as our 8-wheeled locomotives with $16\frac{3}{4}'' \times 24''$ cylinders and $57''$ driving-wheels.

On trial trip, No. 108 hauled 47 loaded 8-wheeled cars up Marimec grade, which is 4 miles long, 45′ to the mile, and combined with curves varying from 2865′ to 1433′ radius. The total weight of engine, tender and train was about 1100 tons (of 2000 lbs.).

So far we are very much pleased with them, and have no doubt their performance will recommend the adoption of this class for the heavy grades on this road.

Very respectfully,

(*Signed*) JOHN HEWITT,

Superintendent of Motive Power and Machinery.

CLASS 10-34 E ON GRADE OF 171 FEET PER MILE AND CURVE OF 300 FEET RADIUS.

CUMBERLAND AND PENNSYLVANIA RAILROAD.

OFFICE OF THE GENERAL SUPERINTENDENT, MOUNT SAVAGE, MD., May 31, 1872.

MESSRS. M. BAIRD & CO.:

Gentlemen,—Agreeably to my promise to give you some results of our experience with the two Consolidation pattern locomotives, Nos. 25 and 26, introduced upon this road early in 1870, I supply below such information as my observation justifies:

Traversing Curves.—We use these locomotives daily with long heavy trains upon curves of 300′ radius. No instance has yet occurred of running off, except once from misplaced switch. Upon easier curves they work, of course, with still greater facility; and in curving, generally, the arrangement of the pilot-wheels is so admirable that I do not hesitate to say the engines curve more easily, both to themselves and the track, than any others within my knowledge.

Steaming.—They steam as freely as could possibly be desired.

Speed.—On account of the character of our road and business (coal transportation almost exclusively), our trains run at a uniform speed of 9 to 10 miles per hour only. My opinion is they would haul heavy trains on a level road, or one of easy grades, safely at 25 miles per hour.

Tractive Power.—We have never tested the *ultimate power* of the engines, but can say what they do daily. Over a section of our road, where the grade is 171′ per mile, they take up readily on dry rail, without sanding rail, 32 empty cars, weighing 160 gross tons. My opinion is that with the use of sand they would take up a load equal to 200 gross tons.

In descending grades the train is controlled by the car brakes—no pulling by the engine. When running "empty" the tender brakes suffice.

One point you do not ask about, and it enters largely into any comparisons which it may be desirable to institute—the expense of maintenance.

Upon this road, where we steam up freely in ascending, the pressure is allowed to fall in going down grades. The engines make 2 to 2½ round trips daily over a section of 17 miles. The variations, therefore, in the pressure and other conditions will ever make the service severe on machinery.

In 1870, after a year's severe service, our locomotive repairs cost the *average* of 35¼ cents per mile run for all our 31 locomotives.

No. 25 ran 13,025 miles; cost $5\frac{9}{10}$ cents per mile.
" 26 " 11,908 " " $7\frac{6}{10}$ " "

In 1871, *average* repairs of all were $17\frac{8}{10}$ cents per mile.

No. 25 ran 18,825 miles; cost 5 cents per mile.
" 26 " 19,247 " " $5\frac{1}{10}$ " "

It is true the engines are comparatively new. They have had no accidents, which with some others served to raise the general average, but still the relative economy secured by yours are so marked and so decided that I can truthfully say that in all respects, *service, traction, expense, safety,* they are, in my opinion, the most admirable freight locomotives ever constructed.

Yours truly,

C. SLACK,
General Superintendent.

Central Railroad of New Jersey.

Office of the Assistant General Superintendent, Elizabeth, N. J., May 17, 1880.

Messrs. Burnham, Parry, Williams & Co.,
Baldwin Locomotive Works, Philadelphia, Pa.:

Dear Sirs,—Yours of the 12th inst. is at hand and noted. Memorandum of the performance of the Consolidation engine is correct, as follows:

Phillipsburg to Hampton Junction	16 miles.
Grade	23′ per mile.
Train hauled	100 loaded 4-wheeled coal cars.
Weight of each car empty	3½ gross tons.
Weight of load in each car	6 gross tons.
Schedule time	1 hour and 45 minutes.
Quantity of water consumed	about 3000 gallons.

Yours truly,

(*Signed*) W. W. STEARNS,
Assistant General Superintendent.

The following letters from W. B. Strong, Esq., Vice-President and General Manager, Atchison, Topeka and Santa Fé Railroad Company, and from Jas. D. Burr, Esq., of the Engineer Department of the Atchison, Topeka and Santa Fé Railroad Company, give particulars of the character of the track and the performance of a Consolidation locomotive, the "Uncle Dick," shown by line drawing on page 101, and which is substantially the same as Class 10–36 E, page 105.

Atchison, Topeka and Santa Fé Railroad Company.

Office Vice-President and General Manager, Topeka, Kan., March 31, 1879.

Messrs. Burnham, Parry, Williams & Co.,
Baldwin Locomotive Works, Philadelphia, Pa.:

Gentlemen,—Your favor of the 17th duly at hand. "Uncle Dick" has hauled 9 loaded cars, carrying 12 tons on a car, over the Switchback, the grade being 316′ to the mile and 16° curve. I think it not unlikely it would have handled 1 more car, but I did not propose to take any chances of overloading the engine on that track.

Yours truly,

(*Signed*) W. B. STRONG.

ATCHISON, TOPEKA AND SANTA FÉ RAILROAD COMPANY.
OFFICE OF THE CHIEF ENGINEER, TRINIDAD, COL., March 5, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—Your favor of February 20th, with weight and dimensions of the "Uncle Dick" received, for which please accept my thanks.

The road over which the "Uncle Dick" operates is 15 miles long: Trinidad to Morley, 10 miles. Morley to New Mexico State Line, 4 miles. Switchback is 2¾ miles farther, to cross Raton Mountain Range while the Tunnel (2000′ long) is in the course of construction.

From Trinidad to Morley the road follows the valley of the Purgatoire River for 2 miles; thence crossing this stream, the road follows up Raton Canon with nearly a uniform gradient of 2′ per 100′ (105′ 6″ per mile). From Morley to the Tunnel we have for 3 miles of the way a maximum of 3½′ per 100′. On this portion of the line the maximum curve is 10° (574′), and on all curves there is a compensation at the rate of .05′ per degree per 100′. The curves are very frequent, and the average curve will be about 7°. The outer rail at first was elevated ½″ per degree.

On the Switchback you will notice from the map I send you that the maximum curve is 16°, and gradient 6′ per 100′.

Very respectfully yours,

(*Signed*) JAS. D. BURR,
Assistant Engineer.

TRINIDAD, COL., May 1, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
PHILADELPHIA, PA.:

Herewith please find a report of the performance of the locomotive "Uncle Dick," as promised you, on our Mountain Division of this road.

The engine was intended more especially to meet the requirements of operating the temporary track over the mountain during the progress of work on the tunnel at Raton Pass.

DISTANCES AND GRADIENTS.

	Distance in Miles.	Total Rise. Feet.	Total Fall. Feet.	Grade in Feet per Mile.	Maximum Curvature.	Total Curvature. Degrees.	Average Gradient Feet per Mile.
Trinidad to Morley .	10	800	1.5	105.6	10°	865°06′	80
Morley to Tunnel . .	5.1	766	3.0	184.8	10°	945°44′	150.2
Switchback	2.75	275	275	316.8	16°	1081°13′	

On the 2 per cent. incline, Trinidad to Morley, length of maximum gradient = 31,800′.

On the 3½ per cent. incline, Morley to Tunnel, length of maximum grade = 19,100′.

The 275′ rise on the north side of the mountain, Switchback line, is made in 7000′, there being also 471½° of 16° curves.

The performance of the "Uncle Dick," not including the weight of engine, is as below:

On 2 per cent. gradients	482½ tons,	hauled at 8 miles per hour.
" 3½ " "	258½ "	" 8 " "
Switchback, 6 per cent. maximum . .	194 "	" 6 " "

The last rate includes also the time consumed in opening and closing 6 switches.

The most successful day's work in the mountain has been leaving Trinidad at 7 A.M. with 15 loaded cars and tank of coal and water to Morley; Morley to Tunnel, 10 loaded cars; Switchback, during the day, 46 loaded cars from the north to the south side, and bringing back as many in return, and then reaching Trinidad again at 7 in the evening. During the day 2½ hours were lost in waiting for connections and for dinner.

The ordinary round trip with loads over the Switchback, 2¾ miles, consumes 50 minutes. Average

train, 7 loaded cars of 43,000 lbs. each, and tank 44,000 lbs., although 8 cars, and at one time 9 cars, have been taken over the temporary line. So that 10 round trips, with 7 cars each trip, can readily be made during any one day, or a total of over 6,000,000 lbs. moved over the Switchback in one day is entirely within the locomotive's capacity.

The performance of 2 ordinary American engines on the same line is submitted by way of comparison. Engines coupled, 1 of 17″ × 24″ cylinders, the other 16″ × 24″ cylinders, both engines in good condition.

Leaving Trinidad for tunnel, 15 miles, with their train, and returning at 7 P.M., 34 loaded cars was the greatest number transferred over the Switchback in one day, and bringing back as many in return. So that under the best conditions the "Uncle Dick" is more than equal in capacity to 2 ordinary engines on steep incline, while the cost of fuel and engine service is but little more than for 1 engine of the American type.

Taking the 2 per cent. gradient the resistance is

$$\text{Gravity} \quad \frac{2 \times 2000}{100} = 40 \text{ lbs. per ton.}$$

Wheel friction $= 6$ lbs. per ton.

Wind (say) $= 1.8$ lbs. per ton.

Total resistance, 47.8 lbs. per ton.

Traction, including weight of engine $=$

$$542.5 \times 47.8 = 25931$$

Weight of engine on drivers $= 100{,}000$

$$\text{Adhesion} = \frac{25931}{100{,}000} = \frac{1}{3.86}$$

On the 6 per cent. gradient we have

$$\text{Gravity} \quad \frac{6 \times 2000}{100} = 120 \text{ lbs. per ton.}$$

Wheel friction $= 6$ lbs. per ton.

Wind (say) $= 1.8$ lbs. per ton.

Total resistance, $127.8 = 32461$ lbs.

Traction $= 254 \times 127.8 = 32461$

$$\text{Adhesion} = \frac{32461}{100{,}000} = \frac{1}{3.08}$$

The above loads are started from a standstill without taking the slack of the train, and without slipping the driving-wheels.

The difference of adhesion on the 2 per cent. and on the 6 per cent. gradients is owing to the fact that the load on the 2 per cent. incline is not the full load.

The locomotive passes readily through 16° curves, when the outer rail is elevated at a rate of ¼″ per degree.

Respectfully,

J. D. BURR,
Assistant Engineer.

GEO. HACKNEY,
Superintendent L. and C. D.

CLASS 10-34 E ON GRADES OF 76 AND 126 FEET PER MILE.

Locomotives of this class have been used on the Lehigh Valley Railroad since 1866, in which year the locomotive "Consolidation," from which the class has taken its name, was built by the Baldwin Locomotive Works in accordance with the plan and specifications furnished by Mr. Alexander Mitchell, then Master Mechanic of the Lehigh and Mahanoy Railroad.

On this division of the Lehigh Valley Railroad, over maximum grades of 126′ per mile, the maximum load is 35 loaded 4-wheeled coal cars (329 gross tons of cars and lading), and the usual load 25 loaded 4-wheeled coal cars (235 gross tons of cars and lading). On the same division, over a grade of 76′ per mile, one of these engines draws a maximum train of 140 empty 4-wheeled cars (476 gross tons) at a speed of 8 miles per hour. Its usual train is 100 empty cars (340 gross tons).

On the Wyoming Division of the same railroad, from Sugar Notch to Fairview, the grade is 1′ in 55′ (96′ per mile) for 12 miles in length, combined with curves of 8° and 10° radius. The curves are frequent, and there are but two tangents, each less than 1 mile long, in the whole 12 miles. Up this incline, engines of this class can take 40 loaded 4-wheeled coal cars. The usual train is 35 such cars, which are taken at a speed of 12 miles per hour. The cars weigh, each, 3 gross tons 8 hundredweight, and carry, each, 6 gross tons of coal. The weight of train, therefore, which a Consolidation engine takes up the grade combined with curves, as stated, is from 329 to 376 gross tons.

CLASS 10-34 E ON GRADES OF 96 AND 130 FEET PER MILE.

LEHIGH VALLEY RAILROAD COMPANY.

SUPERINTENDENT'S OFFICE, MAHANOY DIVISION, MAUCH CHUNK, PA., May 8, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—Engine No. 169, Consolidation pattern, of your build, came on this road March 25, 1872, and in the first five years made a mileage of 112,008 miles. Average annual mileage, 22,400 miles.

The cost for repairs during the five years was $3739.50, equal to .03⅓ cents per engine mile.

The work done by the engine was as follows:

Average number of empty cars on a grade of 96′ per mile, 100.
" " " loaded " " " 130′ " 30.

The cars are 4-wheeled coal cars, each weighing about 3 tons 8 hundredweight, and each with a capacity of about 6 tons (of 2240 lbs.) of coal.

Truly yours,

JAMES I. BLAKSLEE,

Division Superintendent.

CLASS 10-34 E ON GRADES OF 53 TO 68 FEET PER MILE, COMPARED WITH 17×24 "AMERICAN" TYPE.

CHICAGO, BURLINGTON, AND QUINCY RAILROAD COMPANY.

OFFICE OF SUPERINTENDENT LOCOMOTIVE AND CAR DEPARTMENTS,

T. J. POTTER, ESQ., AURORA, ILL., August 19, 1880.

ASSISTANT GENERAL MANAGER, CHICAGO:

Dear Sir,—In reply to yours of July 30th, requesting answer to letter of Baldwin Locomotive Works, hereto attached, would say that the performance of Consolidation engines on the Iowa Division is as follows:

The engines are run between Creston and Chariton, a distance of 60 miles, which run is doubled, making 120 miles each day.

The maximum grade going east is 68.6′ per mile, 11,600′ long, of which 1400′ have a curvature of 2° 30′; 1300′ a curvature of 3°; and 100′ a curvature of 2° 40′.

The maximum grade going west is 67.58′ per mile, 7300′ long, of which 1400′ have a curvature of 2°, and 2600′ a curvature of 3° 12′.

Going east the train consists of 29 cars, engine, tender, and way car. The freight cars will average 15-ton loads. Going west we can haul 1 additional loaded freight car.

For additional data, would say that the Consolidation engines will haul between Burlington and Lefflers 40 loads and way car. The grade is 52.8′ per mile, 10,100′ long, of which 1200′ have a curvature of 2° 20′, and 2300′ a curvature of 1° 26′. The engines will stop and start this train on any part of the grade.

Engine-men on Consolidation engines receive the same pay as engine-men on the ordinary 8-wheeled American engine. Only 1 fireman is employed, but an additional brakeman is needed to handle trains.

To compare the performance of Consolidation engines with our ordinary 38-ton 8-wheeled engines, 17″ × 24″ cylinders, 5-feet driving-wheels, will state that these engines will haul between Creston and Chariton 18 loads and way car east, and 19 loads and way car west. They will haul 24 loads up Burlington grade.

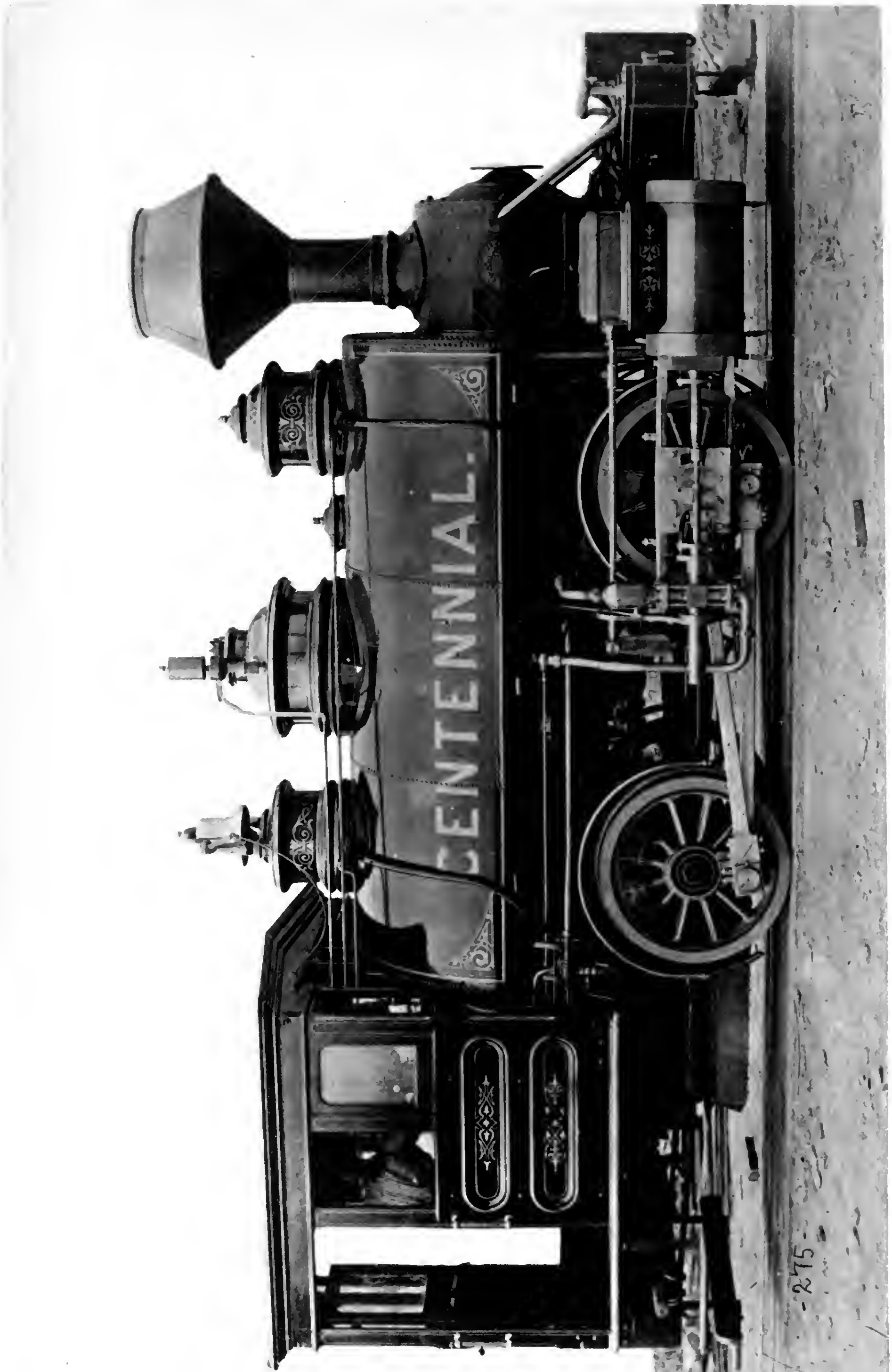
The consumption of coal for both classes of engines for a period of 3 months, April, May, and June, 1880, stands as follows:

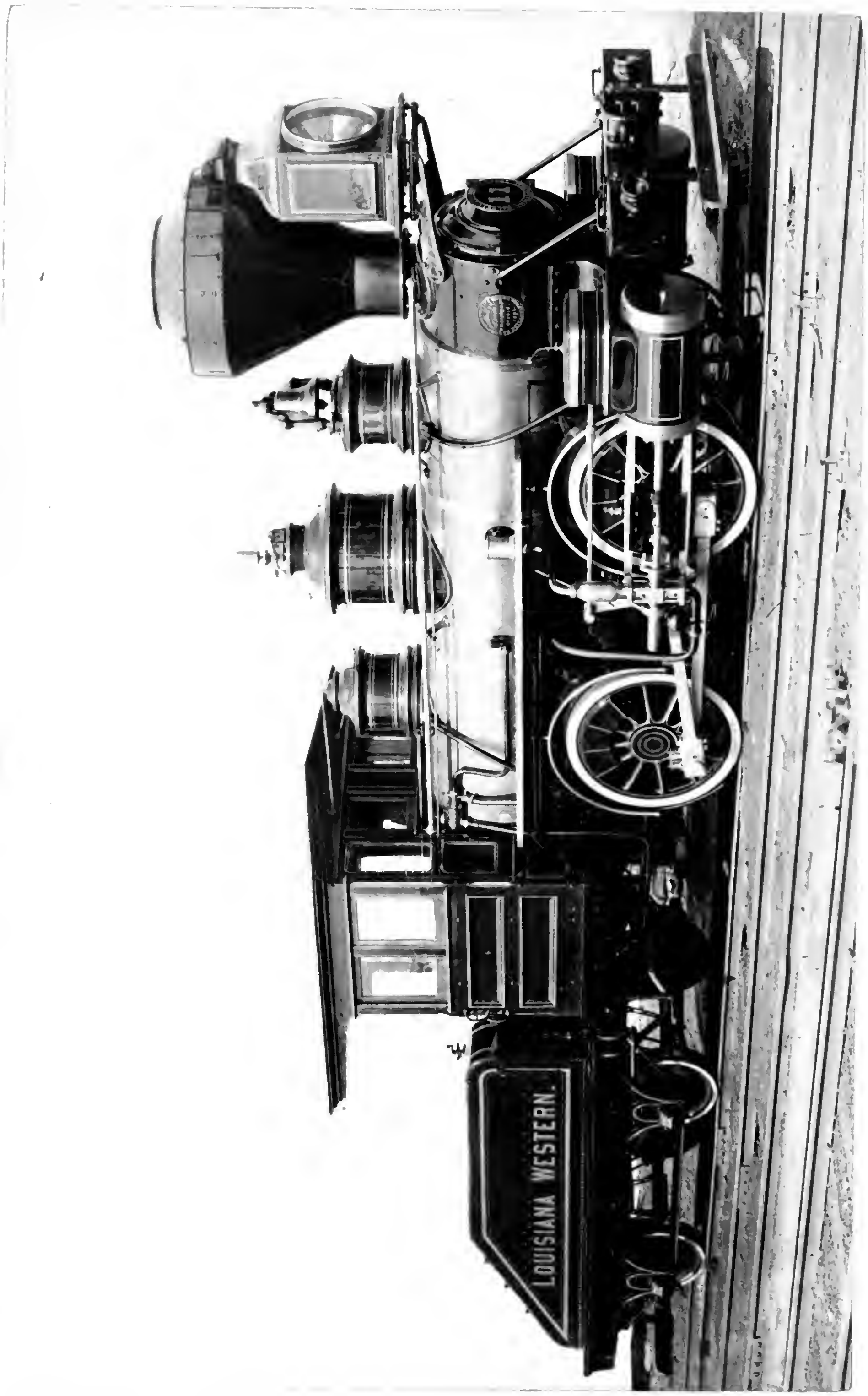
Consolidation engines, Nos. 325 and 326, average miles to ton of coal . .	15.7
17″ × 24″, 38-tons engines	19.0

Yours truly,

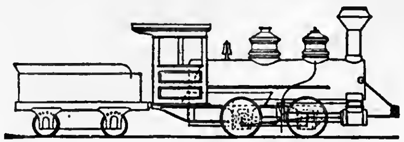
(*Signed*) H. B. STONE.

(NOTE.—The tons above given are net tons of 2000 pounds each.)


CENTENNIAL.


LOUISIANA WESTERN.

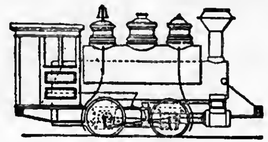
FOUR-WHEELS-CONNECTED SWITCHING LOCOMOTIVES,



WITH SEPARATE TENDERS OR TANKS ON BOILERS.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR COAL.

General Designs as Photographs on pages 118 and 120, and as annexed Cuts.



DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SEVEN SIZES OF THIS PATTERN.

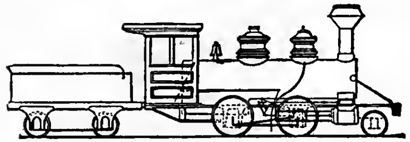
CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.				Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.		Total.		Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft.	*In.*	*Ft.*	*In.*											
4-14 C	10 × 16	37	6		6		400	750	24,000	24,000	580	250	150	100	75	60	50
4-16 C	11 × 16	37	6		6		450	800	30,000	30,000	700	310	185	130	95	75	60
4-18 C	12 × 16	37	6		6		500	900	35,000	35,000	815	355	230	160	120	100	80
4-20 C	13 × 18 or 20	37 to 41	6		6		600	1000	39,000	39,000	1080	475	275	195	145	115	95
4-22 C	14 × 22 or 24	43 to 49	7		7		700	1600	45,000	45,000	1280	560	335	230	170	135	110
4-24 C	15 × 22 or 24	43 to 49	7		7		800	1600	49,000	49,000	1430	630	375	260	195	154	124
4-26 C	16 × 22 or 24	43 to 49	7	6	7	6	900	1800	56,000	56,000	1635	720	430	300	225	175	140

In referring to any of the above classes, it should be stated whether a locomotive with separate tender or with tank on boiler is meant.

In case of a locomotive with separate tender, the tender can be 4-wheeled, 6-wheeled, or 8-wheeled, as preferred, according to capacity required.

The weights given in above table and the figures for loads to be hauled are predicated on locomotives with separate tenders. A tank engine of any given class would weigh approximately, when tank is full, 8⅓ pounds in addition for each gallon in tank. Thus Class 4-26 C would weigh about 64,000 pounds, with tank, containing 900 gallons of water, on boiler. The tank engine could also draw an additional load equal to the weight of the tender omitted,—say from 10 to 20 tons.

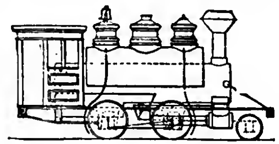
FOUR-WHEELS-CONNECTED AND LEADING PONY-TRUCK LOCOMOTIVE



WITH SEPARATE TENDER OR TANK ON BOILER, FOR SWITCHING OR LOCAL SERVICE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, COAL.

General Designs as Photographs on pages 123 and 125, and as annexed Cuts.



DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

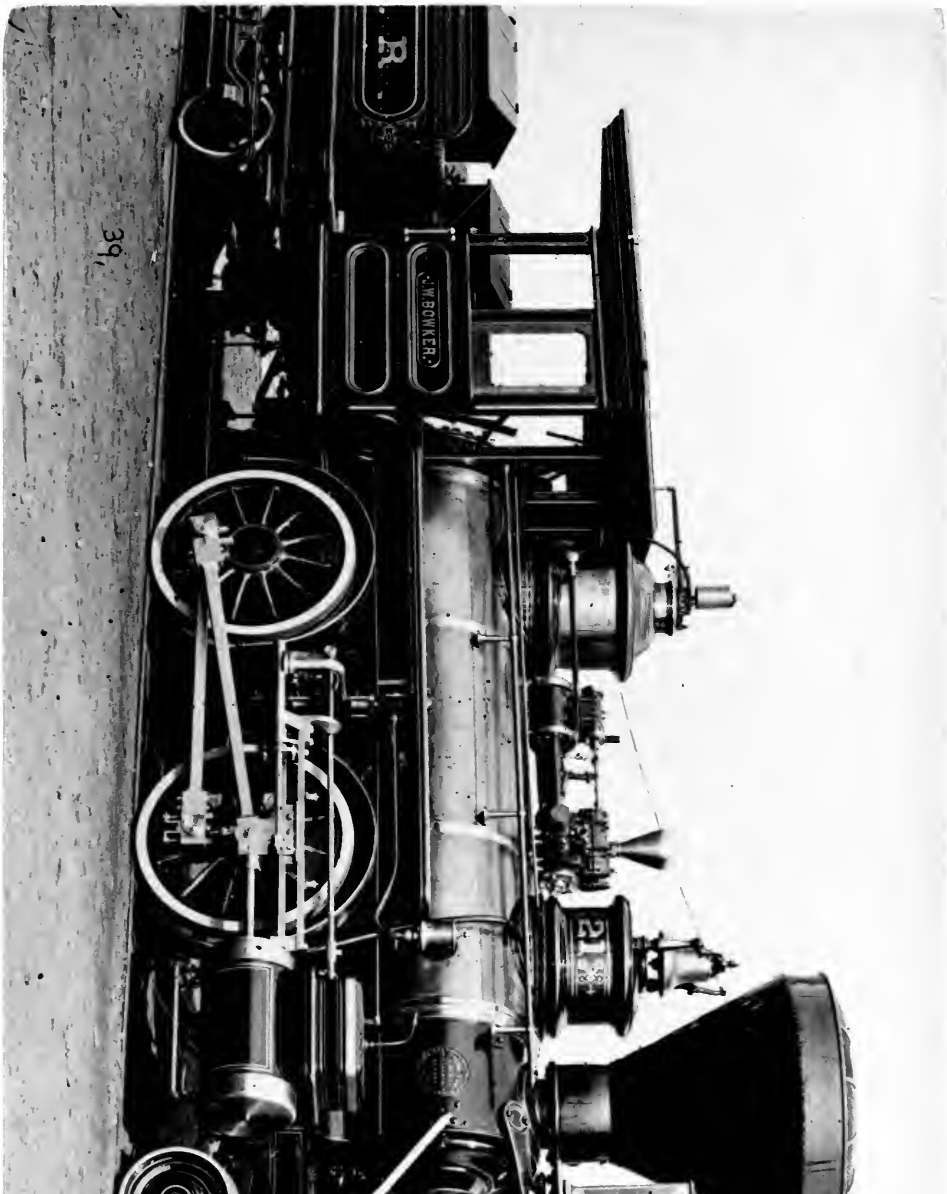
CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.				Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.		Total.		Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
												26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft.	*In.*	*Ft.*	*In.*											
6-14 C	10 × 16 or 18	37 to 41	6	6	12	4	400	750	28,000	21,000	580	250	150	100	75	55	45
6-16 C	11 × 16 or 18	37 to 41	6	6	12	4	450	800	32,000	24,000	695	305	180	125	90	70	55
6-18 C	12 × 16 or 18	37 to 43	7		13	4	500	900	38,000	30,000	815	355	230	160	120	100	80
6-20 C	13 × 18 or 20	41 to 45	7	4	14	8	550	1000	42,000	34,000	990	435	260	175	130	105	85
6-22 C	14 × 22 or 24	43 to 49	7	4	14	9	700	1600	48,000	40,000	1165	510	305	210	155	120	100
6-24 C	15 × 22 or 24	43 to 49	7	4	14	9	800	1600	52,000	44,000	1280	560	335	230	170	135	110

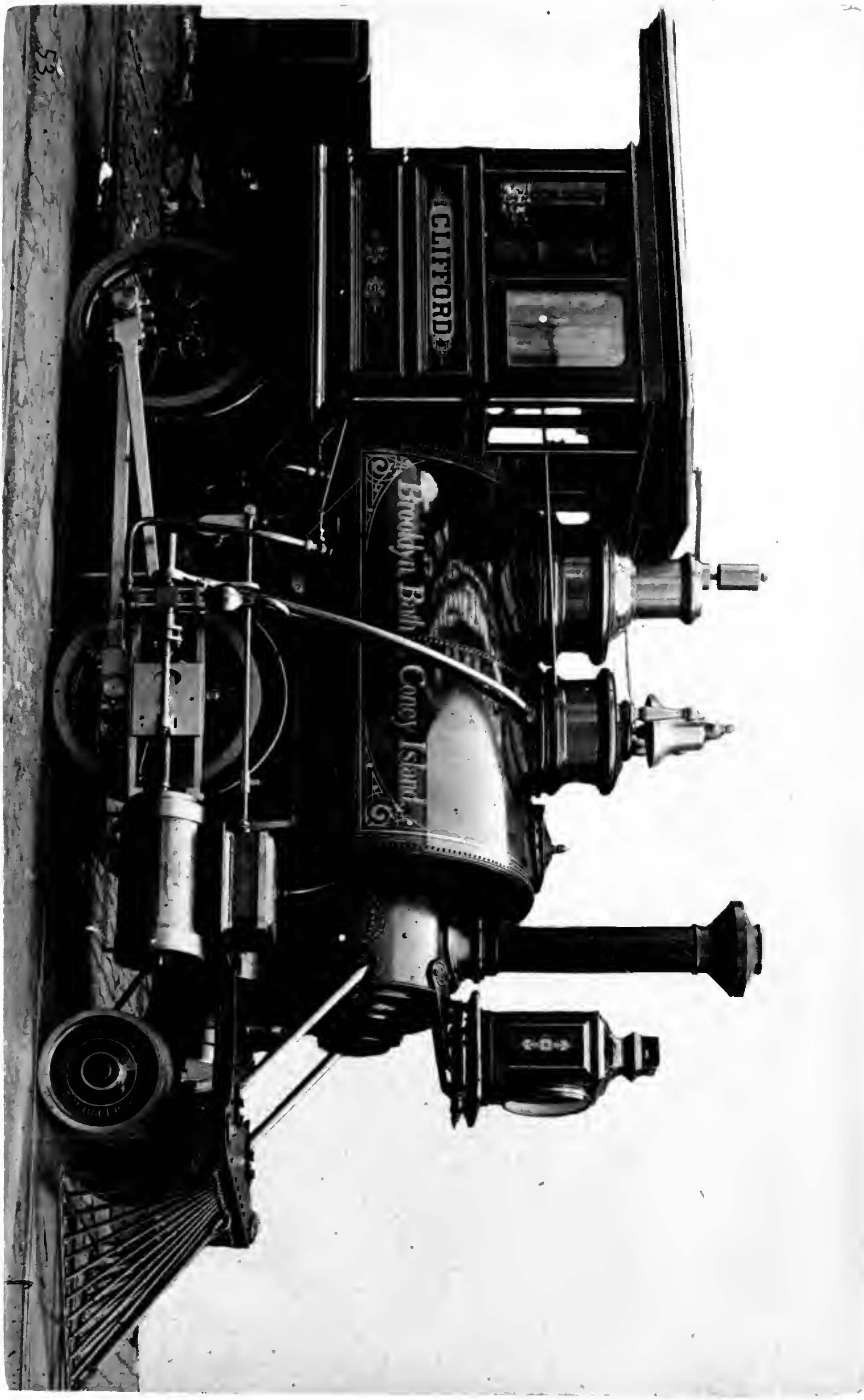
This plan of engine necessarily has a shallow fire-box placed over rear driving-axle. It is, therefore, best adapted to burning coal.

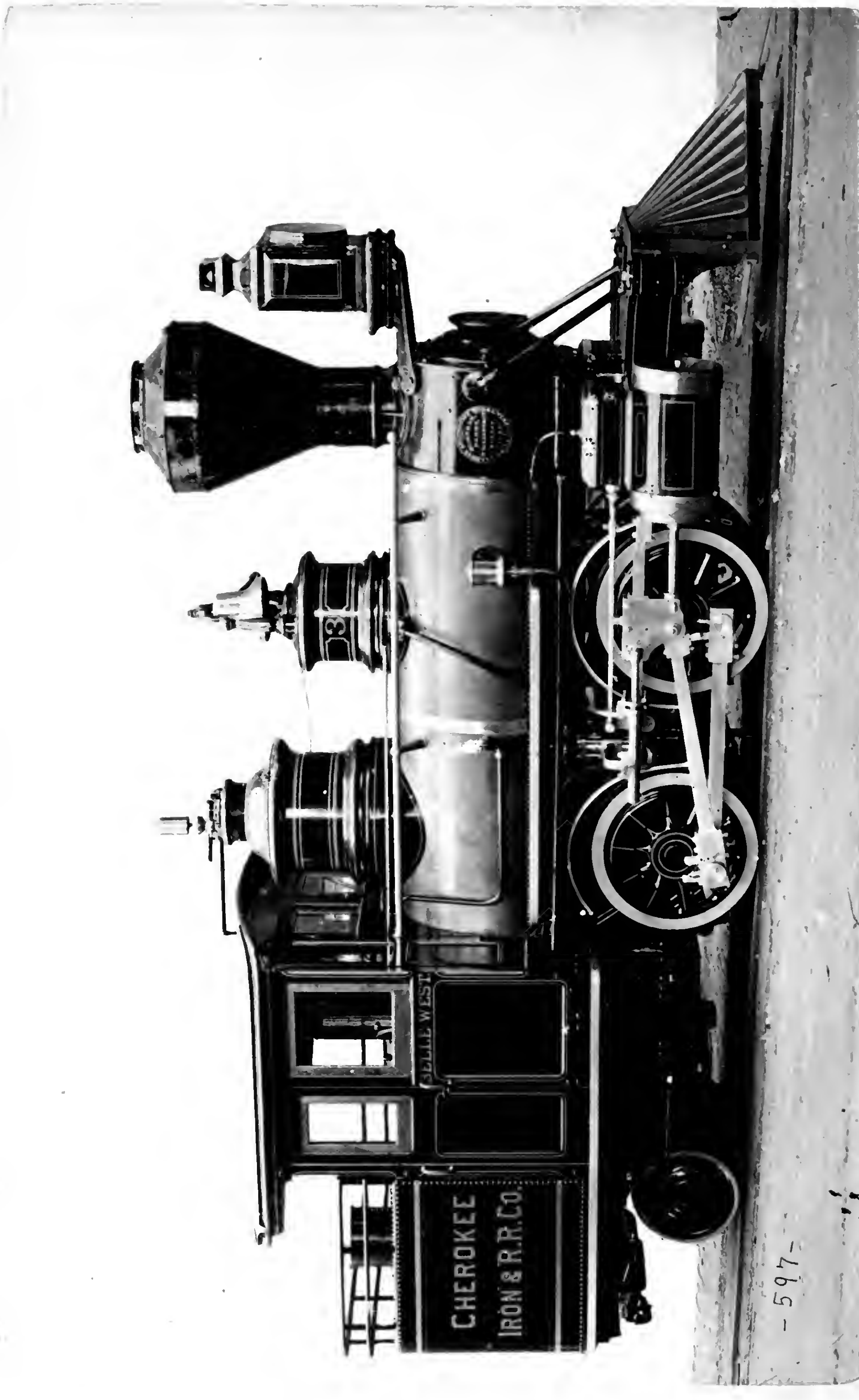
Two pairs of wheels are equalized together longitudinally, either the coupled-wheels, or the front driving-wheels with the pony-truck.

The pony-truck has a swinging bolster and radius-bar. Owing to the action of the truck, the shortness of the total wheel-base, and the short spread of the coupled-wheels, an engine of this type, when running with the truck ahead, can traverse readily the sharpest curves.

The weights given in above table and the figures for loads to be hauled are predicated on locomotives with separate tenders. A tank engine of any given class would weigh approximately, when tank is full, 8⅓ pounds in addition for each gallon in tank. Thus Class 6-24 C would weigh about 59,000 pounds, with tank, containing 800 gallons of water, on boiler. The tank engine could also draw an additional load equal to the weight of the tender omitted,—say from 10 to 20 tons.


W.BOWKER.


CLIFFORD
Brooklyn Bath Coney Island


CHEROKEE
IRON & R.R. Co.
BELLE WEST
-597-

FOUR-WHEELS-CONNECTED AND TWO-WHEELED TRAILING TRUCK LOCOMOTIVES, "FORNEY" TYPE,

FOR SWITCHING AND LOCAL SERVICE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR COAL.

General Design as Photograph on page 128.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	Ft. In.											
6-14⅓C	10 × 16 or 18	37 to 41	5	11 6	400		30,000	23,000	585	255	155	105	80	60	50
6-16⅓C	11 × 16 or 18	37 to 41	5	11 9	450		34,000	26,000	700	310	185	130	95	75	60
6-18⅓C	12 × 16 or 18	37 to 43	6 6	13 3	500		40,000	30,000	820	360	235	165	125	105	85
6-20⅓C	13 × 18 or 20	41 to 45	6 6	13 6	550		46,000	35,000	1000	445	265	185	140	115	95
6-22⅓C	14 × 22 or 24	43 to 49	7	14 8	600		56,000	44,000	1290	570	345	240	180	145	120
6-24⅓C	15 × 22 or 24	43 to 49	7	15 3	650		60,000	47,000	1380	615	370	260	195	155	130

This plan of locomotive is especially adapted to switching service, and to short runs at moderate speed, and where a limited quantity of fuel and water will suffice. Having six wheels, it is comparatively steady in its motion. The fuel and water are carried at the back end of the engine, on and in the tank over the truck. The driving-wheels are equalized together, so that the weight of the boiler and machinery is carried on equalizing levers midway between the driving-wheels. The pony-truck, under the tank, has a swinging bolster and radius-bar.

This plan of engine admits of a large fire-box of ample length and width. A separate tender can be attached, if desired, in lieu of the tank behind the cab. The weights given in table include water in tank.

FOUR-WHEELS-CONNECTED AND FOUR-WHEELED TRAILING TRUCK LOCOMOTIVES, "FORNEY" TYPE,

FOR SWITCHING AND LOCAL SERVICE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR COAL.

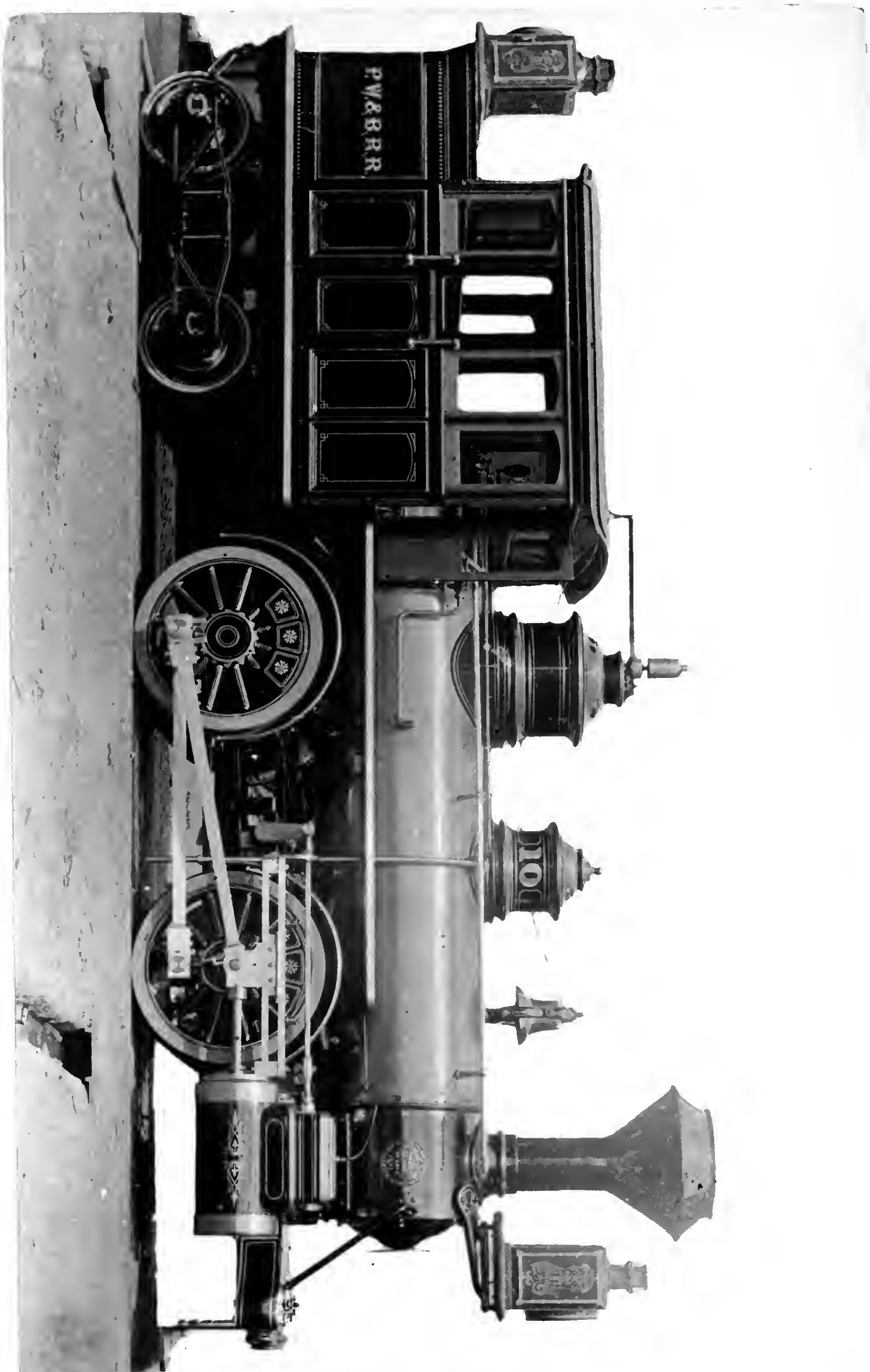
General Design as Photograph on page 131.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF EIGHT SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
										On a Grade per Mile of					
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	*Ft. In.*											
8-14⅓ C	10 × 16 or 18	37 to 41	5	16 1	450		32,000	23,000	585	255	155	105	80	60	50
8-16⅓ C	11 × 16 or 18	37 to 41	5	16 1	500		36,000	25,000	700	310	185	130	95	75	60
8-18⅓ C	12 × 16 or 18	37 to 43	6 6	17 6	600		42,000	30,000	820	360	235	165	125	105	85
8-20⅓ C	13 × 18 or 20	41 to 45	6 6	18	650		48,000	35,000	1000	445	265	185	140	115	95
8-22⅓ C	14 × 22 or 24	43 to 49	7	18 9	700		58,000	44,000	1290	570	345	240	180	145	120
8-24⅓ C	15 × 22 or 24	43 to 49	7	19 3	750		62,000	47,000	1380	615	370	260	195	155	130
8-26⅓ C	16 × 24	49	7	19 10	800		68,000	52,000	1500	665	400	280	210	165	135
8-28⅓ C	17 × 24	49	7 6	20 9	850		75,000	58,000	1700	760	455	320	235	190	160

The same considerations apply to the above classes as are stated on page 129 for the "Forney" engines with pony (2-wheeled) truck. The use of the 4-wheeled truck, however, increases the tank capacity, and also makes the engine ride somewhat more smoothly. In this respect it is precisely the same in principle when running with truck ahead as the "American" pattern, page 69, as it is carried on two systems of equalized wheels.

Engines of Class 8-14⅓ C are used on the New York Elevated Railway (Third Avenue), passing curves as short as 100′ radius. Similar engines are also used on the Atlantic Avenue branch of the Long Island Railroad. The larger classes have been built for switching service and short runs with passenger and freight trains on various lines. The weights given in table include water in tank.


P.W.&B.R.R.

PERFORMANCE OF "FORNEY" LOCOMOTIVES.

CLASS 8-18⅓ C ON GRADES OF 53 TO 85 FEET PER MILE.

THE NEW YORK AND SEA BEACH RAILROAD COMPANY.

OFFICE OF THE PRESIDENT, NEW YORK, October 25, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—The performance of the Forney locomotives built by you and put in service on the New York and Sea Beach Railroad in July last is indicated in the following figures:

Distance run, Bay Ridge to Coney Island	6 miles.
Maximum grades	53′ to 85′ per mile.
Minimum curves	500′ radius.
Ordinary train	4 passenger cars.
Weight of each car	8½ tons.
Average number of passengers in each car	50
Number of stops made in 6 miles	4
Running time	15 to 18 minutes.
Time frequently made	14 minutes.
Consumption of fuel	20 to 25 ℔. coal per mile run.

The above is the ordinary work done by each of these engines.

On special occasions 11 fully loaded passenger cars have been started out of the station at Bay Ridge and taken over the road at slower speed than as above stated for the ordinary train. The Bay Ridge station is on a grade of 60′ per mile, succeeded by a grade of 85′ per mile. The incline formed by the two grades is about three-fourths of a mile long. Other shorter grades of 85′ per mile occur between Bay Ridge and Coney Island.

Yours truly,

R. E. RICKER,

President.

CLASS 8-18⅓ C ON GRADES OF 58 FEET PER MILE.

SOUTH MANCHESTER RAILROAD COMPANY.

SOUTH MANCHESTER, CONN., October 21, 1879.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—We are very much pleased with the performance of the "Mount Nebo."

Our road is 2¼ miles long. We run 9 passenger trains and 1 freight train every day. The maximum grade is 58.08′ to the mile, and the shortest curve 5°.

We run our passengers and freights separate, and have hauled 15 loaded freight cars with ease over the road. Our running time between two stations (2¼ miles) with a passenger train of 1 to 3 cars is 6 minutes.

Yours, very respectfully,

RICHARD O. CHENEY,

General Manager.

LAKE CHAMPLAIN AND MORIAH RAILROAD COMPANY.

PORT HENRY, N. Y., April 5, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The "Champlain" (Forney pattern engine) does our work cheaper and easier than the "Cedar Point" (engine with tender). Our maximum grade is 220′ to the mile; our shortest curve is 16° on main line. She can haul 13 4-wheeled ore-cars, weighing 3 tons each, at the rate of 10 miles an hour, or 2 double-truck loaded cars weighing 40 tons.

Yours truly,

E. B. HEDDING.

EMMETTSBURG RAILROAD COMPANY.

EMMETTSBURG, MD., April 21, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The Forney pattern of engine purchased of you last January has given excellent satisfaction in her general working, and I am convinced that this style of engine must come into general use, combining, as it does, the weight and the power in such comparatively small compass. It is economical of fuel, easy on the track, and is equal to any work we can have.

Respectfully,

J. TAYLOR MOTTER,

President.

FLINT AND PERE MARQUETTE RAILWAY.

EAST SAGINAW, MICH., April 7, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—The locomotive No. 44, Forney pattern, was ordered and built as a switching engine, and has been retained in that service from the time we received it until the present, sometimes performing heavy work, sometimes light; but this I can say, that as a switching engine it has, so far, given entire satisfaction.

Yours truly,

SANFORD KEELER,

Superintendent.

CLASS 8-28⅓ C ON A GRADE OF 352 FEET PER MILE.

MORGAN'S LOUISIANA AND TEXAS RAILROAD AND STEAMSHIP COMPANY.

NEW ORLEANS, August 11, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

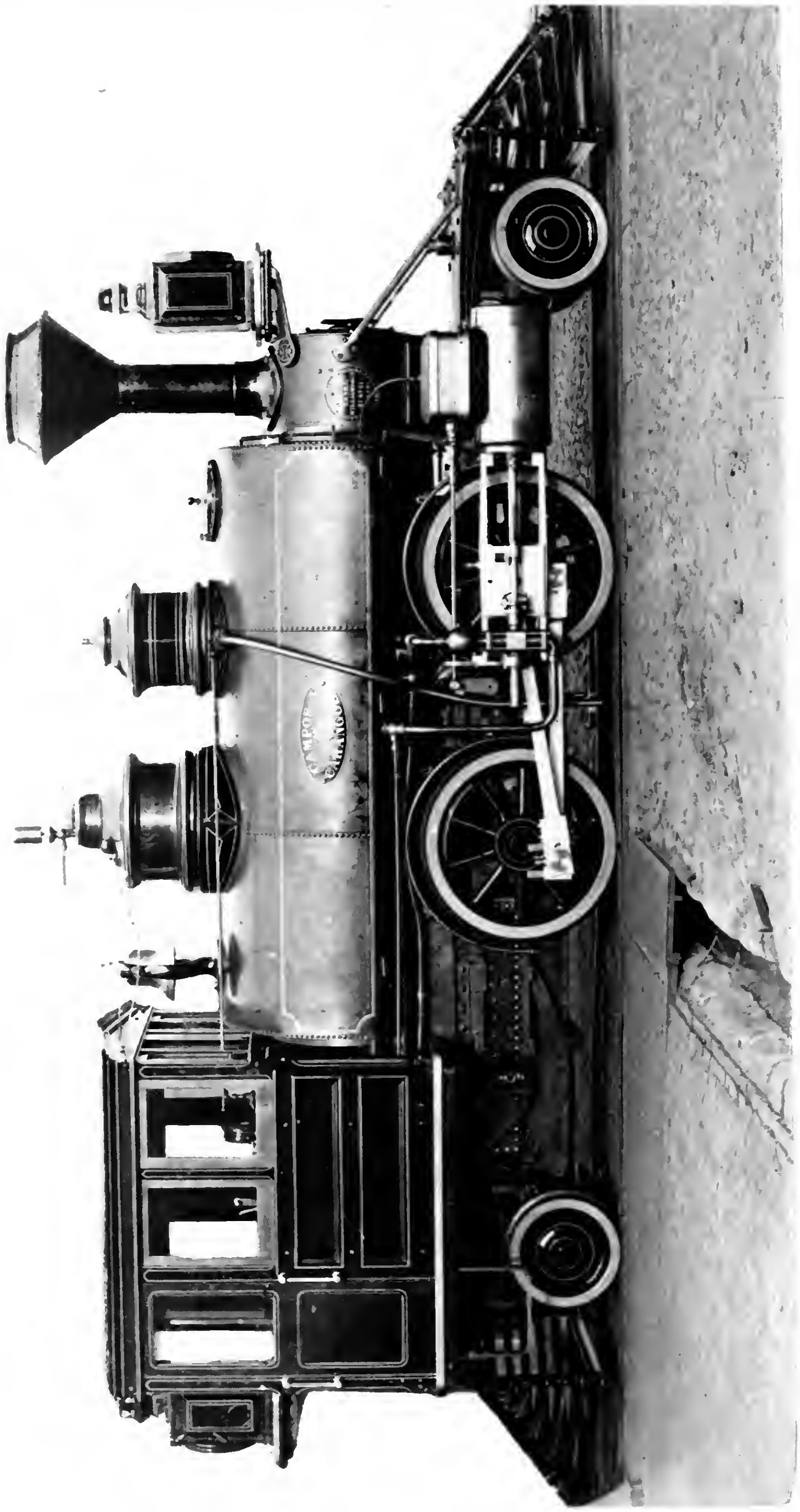
BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—In reply to yours of 6th instant, the two locomotives you furnished for our ferry approaches work admirably, being able to start or stop with a train anywhere on the incline, which is 1′ in 15′. At this time the water is high, making the incline shorter than when the water is low. There is now about 150′ of incline holding, say, 5 cars, the weight of each car being, say, 9 tons, and carrying from 10 to 14 tons of lading, the total weight of cars and lading on the incline being from 95 to 115 tons. At extreme low water the length of the incline will be about 300′, or, say, 9 cars and the locomotive. The engines now do their work so easily that I am satisfied that they will answer all purposes they were intended for.

Very truly yours,

(*Signed*) NEWELL TILTON,

Assistant Sup't and C. E.



"DOUBLE-ENDER" TANK LOCOMOTIVES,

FOR SWITCHING AND LOCAL SERVICE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR COAL.

General Design as shown by Photograph on page 136.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF EIGHT SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.				Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.		Total.		Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
												26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft.	*In.*	*Ft.*	*In.*											
8-14¼ C	10 × 16 or 18	37 to 41	6		18	6	400		35,000	22,000	585	255	155	105	80	60	50
8-16¼ C	11 × 16 or 18	37 to 41	6		18	10	450		38,000	24,000	700	310	185	130	95	75	60
8-18¼ C	12 × 18 or 20	41 to 45	6		19	8	500		44,000	28,000	800	360	215	150	115	90	75
8-20¼ C	13 × 18 or 20	43 to 49	6		20	2	600		49,000	32,000	935	415	245	170	130	100	85
8-22¼ C	14 × 22 or 24	45 to 51	7		21	4	700		56,000	38,000	1115	495	295	205	155	125	100
8-24¼ C	15 × 22 or 24	49 to 55	7		21	8	800		60,000	42,000	1230	545	330	230	175	140	115
8-26¼ C	16 × 22 or 24	49 to 55	7	6	22	6	900		68,000	48,000	1400	625	375	265	200	160	130
8-28¼ C	17 × 22 or 24	49 to 55	7	6	22	10	1000		72,000	52,000	1525	675	405	285	215	170	140

In locomotives of this type each pair of driving-wheels is equalized with the adjacent pair of truck-wheels. Each truck has a swinging or sliding bolster and radius bar. These engines can, therefore, pass short curves freely, and are especially adapted to light switching service, or for light passenger or freight traffic on city or suburban railroads, where short curves are to be traversed with some speed, and where it is desirable to run both ways without turning.

This type of locomotive can be built with separate tender, if desired, instead of tank on boiler.

The weights given in above table are inclusive of water in tank.

DOUBLE-ENDER TANK LOCOMOTIVES,

FOR LOCAL PASSENGER SERVICE.

GAUGE, 4 FEET 8½ INCHES, OR WIDER. FUEL, WOOD OR COAL.

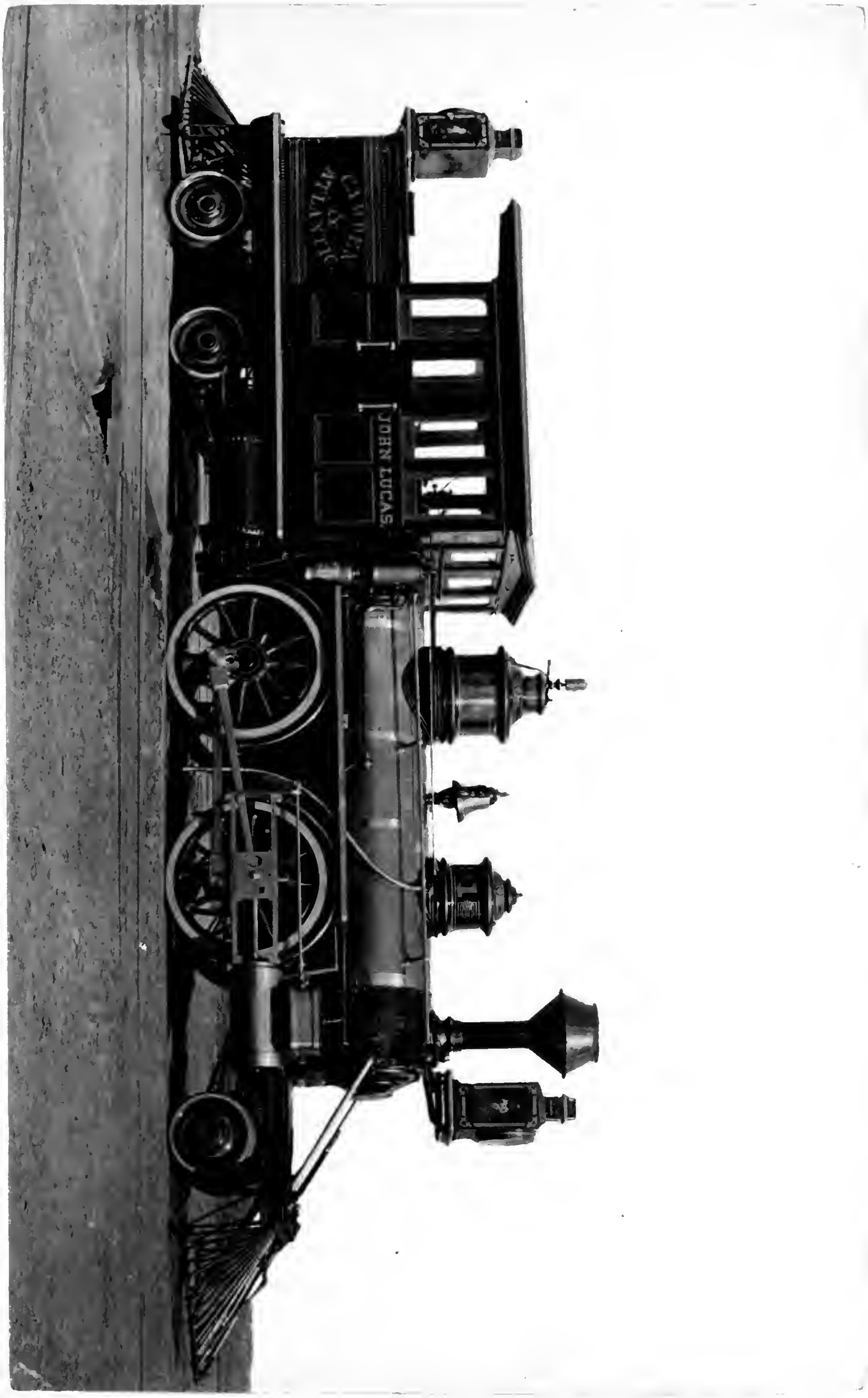
General Design as Photograph on page 139.

DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.		Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.	Total.	Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of 26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft. In.	Ft. In.											
10-16¼C	11 × 18 or 20	43 to 49	6	26 1	650		48,000	24,000	635	275	160	110	80	65	50
10-18¼C	12 × 18 or 20	43 to 49	6	26 1	750		54,000	30,000	815	360	215	145	110	85	65
10-20¼C	13 × 22 or 24	49 to 55	8	27 5	850		64,000	35,000	960	420	250	170	130	100	80
10-22¼C	14 × 22 or 24	49 to 55	8	27 5	1000		70,000	40,000	1130	480	295	200	150	115	90
10-24¼C	15 × 22 or 24	49 to 55	8	29	1100		75,000	43,000	1250	545	330	220	165	130	100
10-26¼C	16 × 22 or 24	55 to 61	8 6	30 1	1200		84,000	45,000	1310	570	340	230	175	140	110

Locomotives of this type are adapted to similar service as the classes previously described (page 85). The 4-wheeled truck under tank, however, admits of a larger tank, and hence greater capacity for both water and fuel.

Three pairs of wheels are equalized together so as to give side bearings for the system so composed; and the remaining two pairs of wheels are equalized together so as to form a centre-bearing truck or combination. The weights given in above table include water in tank.


JOHN LUCAS.

PERFORMANCE OF "DOUBLE-ENDER" LOCOMOTIVES.

CLASS 10-16¾ C IN LOCAL PASSENGER SERVICE.

CAMDEN AND ATLANTIC RAILROAD.

SUPERINTENDENT'S OFFICE, CAMDEN, N. J., September 15, 1880.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gentlemen,—I inclose herewith a report of performance of No. 1 engine (the "John Lucas"), which was placed on the road in March, 1878.

The mileage and cost of repairs for the years 1878 and 1879 have been:

Year.	Mileage.	Cost, in Cents, per Engine Mile.			Total Cost, in Cents, including Wages of Enginemen and Wipers.	
		Repairs.	Fuel.	Oil, Stores, etc.	Per Engine Mile.	Per Car Mile.
1878	33,261	$1\frac{1}{10}$	$5\frac{4}{10}$	$1\frac{14}{100}$	$12\frac{6}{10}$	11
1879	34,907	$1\frac{78}{100}$	$5\frac{9}{10}$	$\frac{70}{100}$	15	$11\frac{3}{10}$

The daily service of the engine is as follows:

Trip.	From	To	Distances. Miles.	Number of Passenger Cars.	Number of Stops.	Time. Minutes.
1	Atco . . .	Camden . .	19.01	1, Atco to Haddonfield, 12 miles . 2, Haddonfield to Camden, 7 miles .	9 8	58
2	Camden . . Haddonfield	Haddonfield Camden . .	6.74 6.74	2 2	4 8	21 20
3	Camden . . Haddonfield	Haddonfield Camden . .	6.74 6.74	1 1	5 5	20 20
4	Camden . . Haddonfield	Haddonfield Camden . .	6.74 6.74	1 1	5 4	20 20
5	Camden . . Lakeside .	Lakeside . Camden . .	11.73 11.73	2 2	10 8	33 33
6	Camden . . Haddonfield	Haddonfield Camden . .	6.74 6.74	2 2	8 8	20 20
7	Camden . . Haddonfield	Haddonfield Camden . .	6.74 6.74	1 1	8 8	20 20
8	Camden . . Haddonfield	Haddonfield Camden . .	6.74 6.74	2 2	5 4	20 20
9	Camden . .	Atco . . .	19.01	2, Camden to Haddonfield . . . 1, Haddonfield to Atco	14	50

The daily run is 143 miles, and the engine is in service night and day, with two engineers and two firemen.

Average daily consumption of coal, 3984 pounds.

Weight of passenger cars hauled, 31,850 pounds each, empty; seating capacity, 60 passengers each.

The engine has frequently made the Lakeside trip with 4 cars, but could not make the time on account of so many stops, losing from 3 to 6 minutes.

It has made the run to Atlantic City (58.6 miles) with 1 and 2 cars, taking water from 5 to 6 times.

The capacity of tank (650 gallons) when engine is drawing 2 cars is sufficient for a run of 20 miles. The highest rate of speed with 1 car has been 55 miles per hour without stops.

The maximum grades between Camden and Haddonfield are about 30′ per mile; between Haddonfield and Atco, 27′ per mile, 3 miles in length.

Very truly yours,

F. A. LISTER,

Superintendent.

CLASS 8-18¼ C ON GRADES OF 40, 44, AND 105 FEET PER MILE.

COVINGTON, KY., January 2, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,

PHILADELPHIA, PA.:

Gentlemen,—Replying to yours of December 26th, I have to say as follows:

The "Double-Ender" is now in daily use hauling an accommodation train of 1 coach and 1 baggage-car 21 miles each way, making an average of 10 stops each way, and at a speed of 20 miles per hour. Maximum grades, 44′ per mile. It consumes 498 lbs. of coal and uses 560 gallons of water each way. It shifts cars during the day in the yard, and handles 15 loaded cars, 20 tons each, with ease.

On special occasions it has hauled 2 coaches and 1 baggage-car at a speed of 25 miles per hour, making 9 stops in the 30 miles run, and using in the distance 647 gallons of water and 690 lbs. of coal. Maximum grade on this run, 40′.

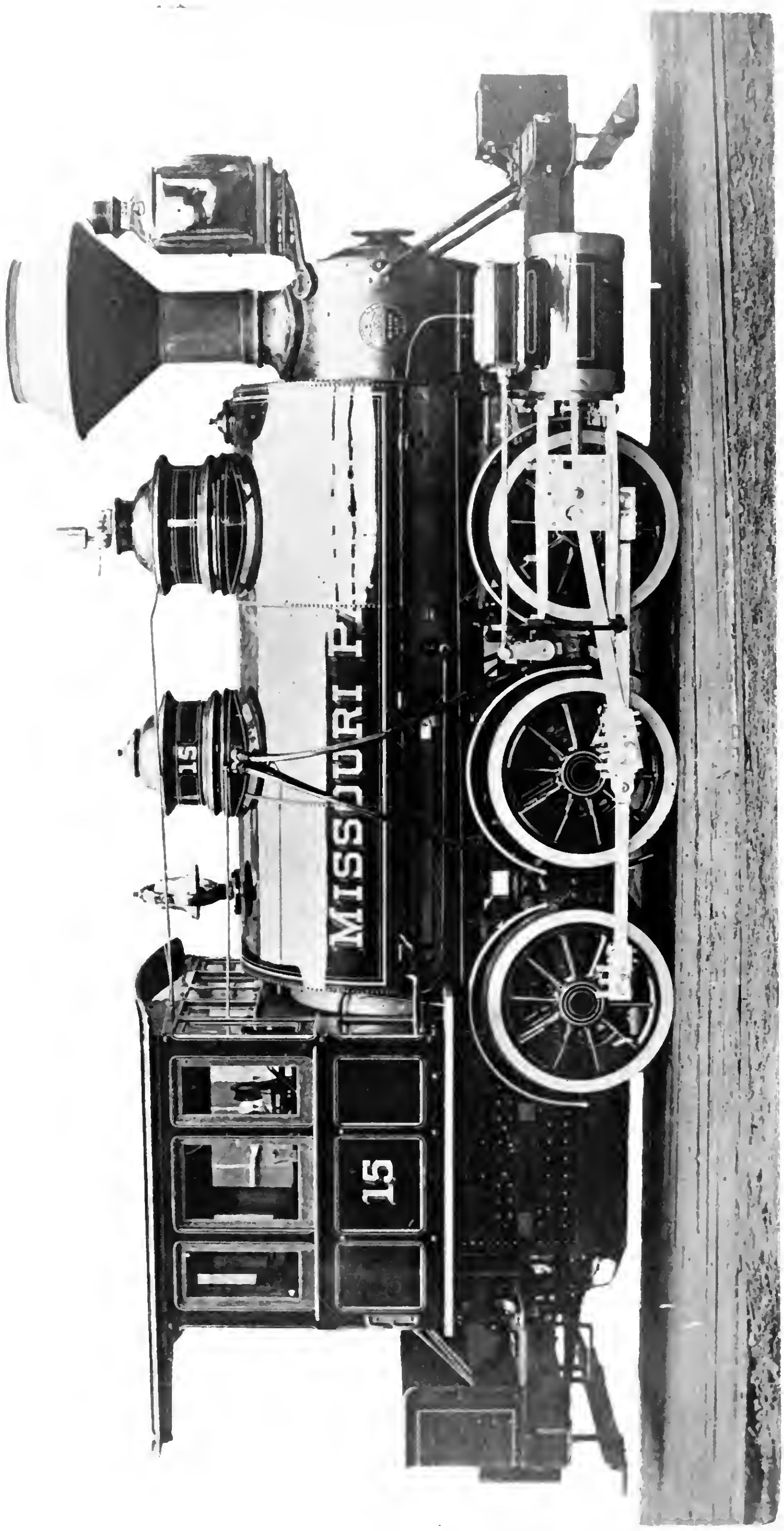
The engine has pulled with ease 4 loaded cars (80 tons) up a 105′ grade 4¾ miles long.

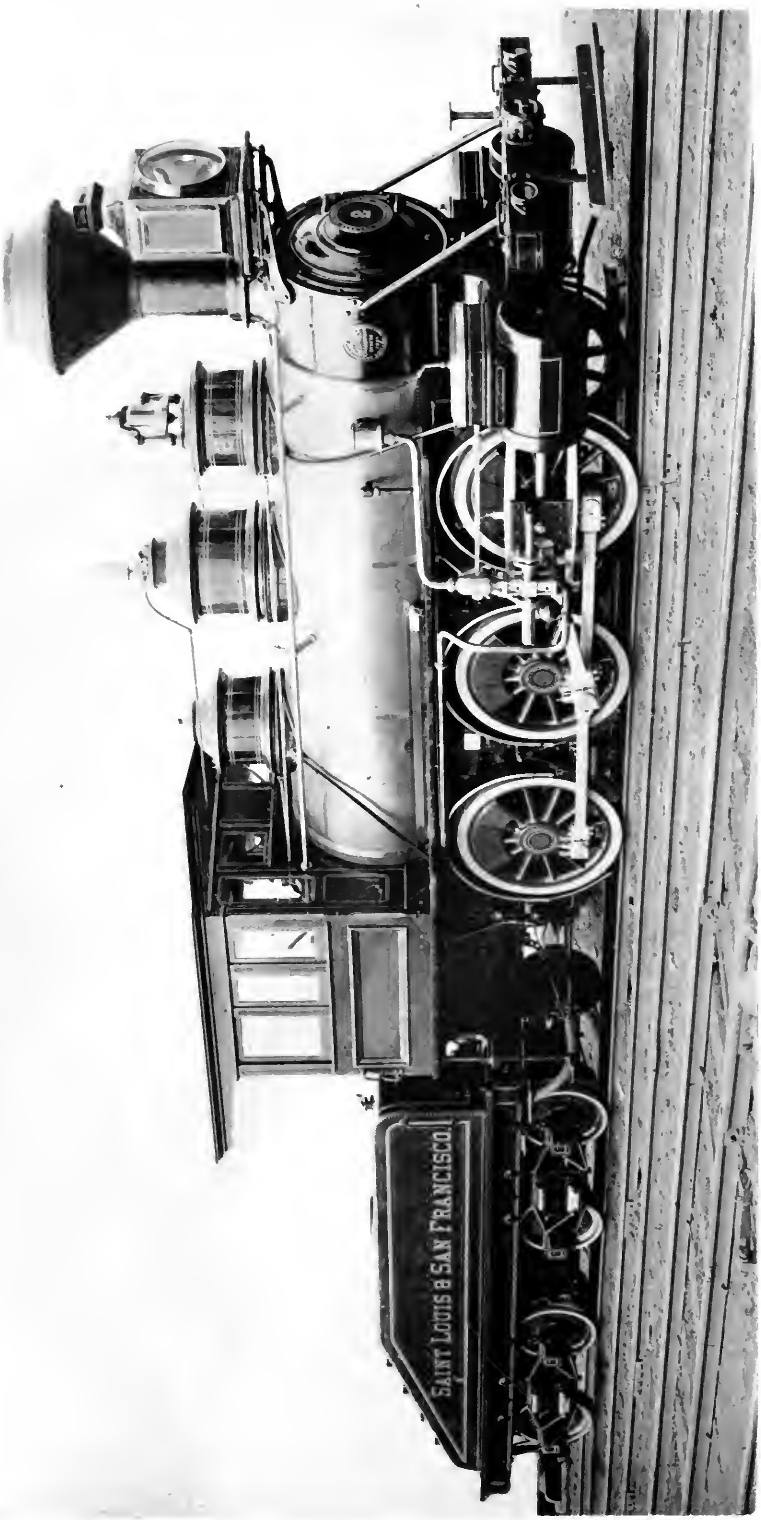
The tank holds water sufficient to run 30 miles, hauling 2 coaches and 1 baggage car, and the coal-bunker holds an abundance of coal for the same train to run 50 miles.

Respectfully,

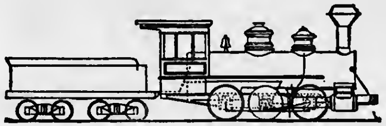
(*Signed*) J. R. LEDYARD,

Assistant Superintendent.


MISSOURI PA
15
15


SAINT LOUIS & SAN FRANCISCO

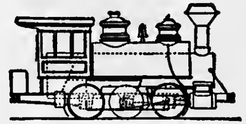
SIX-WHEELS-CONNECTED LOCOMOTIVES,



WITH SEPARATE TENDERS OR TANKS ON BOILERS, FOR SWITCHING OR FREIGHT SERVICE.

GAUGE, 4 FEET 8½ INCHES OR WIDER. FUEL, WOOD OR COAL.

General Designs as Photographs on pages 144 and 146, and as annexed Cuts.



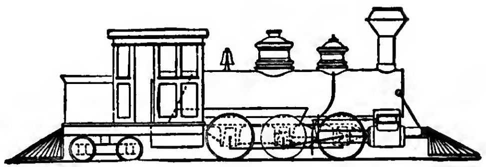
DIMENSIONS, WEIGHTS, AND TRACTIVE POWER OF SIX SIZES OF THIS PATTERN.

CLASS.	Cylinders. Diam. Stroke. Inches.	Diam. of Driving-Wheels. Inches.	Wheel-Base.				Capacity of Tank for Water. 8⅓-Pound Gallons.		Weight in Working Order. Pounds.		LOAD IN TONS (OF 2240 POUNDS) OF CARS AND LADING.						
			Of Driving-Wheels.		Total.		Tank on Boiler or Engine Frames.	Separate Tender.	Total.	On all Driving-Wheels.	On a Level.	On a Grade per Mile of					
												26.4 Feet, or ½ per cent.	52.8 Feet, or 1 per cent.	79.2 Feet, or 1½ per cent.	105.6 Feet, or 2 per cent.	132 Feet, or 2½ per cent.	158.4 Feet, or 3 per cent.
			Ft.	*In.*	*Ft.*	*In.*											
6-22 D	14 × 22 or 24	41 to 45	9	6	9	6	700	1600	52,000	52,000	1340	590	350	240	180	140	115
6-24 D	15 × 22 or 24	41 to 45	10		10		800	1800	57,000	57,000	1545	680	405	280	210	165	135
6-26 D	16 × 22 or 24	45 to 49	10		10		850	2000	63,000	63,000	1630	720	425	295	220	175	145
6-28 D	17 × 22 or 24	45 to 49	10	6	10	6	900	2200	69,000	69,000	1865	820	490	340	255	200	160
6-30 D	18 × 22 or 24	45 to 49	10	6	10	6	1000	2400	74,000	74,000	2075	915	545	380	285	225	180
6-32 D	19 × 22 or 24	49	11		11		1200	2600	78,000	78,000	2280	1005	600	420	315	250	200

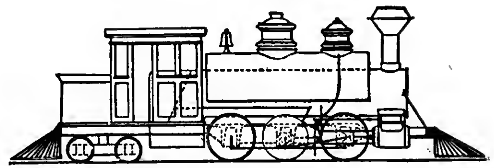
In referring to any of the above classes, it should be stated whether a locomotive with separate tender or with tank on boiler is meant.

In locomotives of this type the rear and main driving-wheels are equalized together, and carry their load at the centres of the side-equalizing beams. The springs of the front driving-wheels are cross-equalized. The main driving-wheels have tires without flanges.

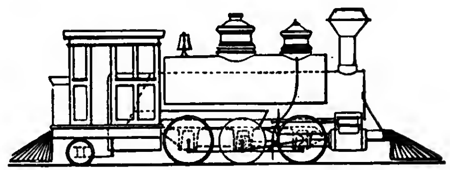
The weights given in above table and the figures for loads to be hauled are predicated on locomotives with separate tenders. A tank engine of any given class would weigh approximately, when tank is full, 8⅓ pounds in addition for each gallon in tank. Thus Class 6-26 D would weigh about 70,000 pounds, with tank, containing 850 gallons of water, on boiler. The tank engine could also draw an additional load equal to the weight of the tender omitted,—say from 15 to 25 tons.



10⅓ D.



10⅓ D,
With additional Tank on Boiler.

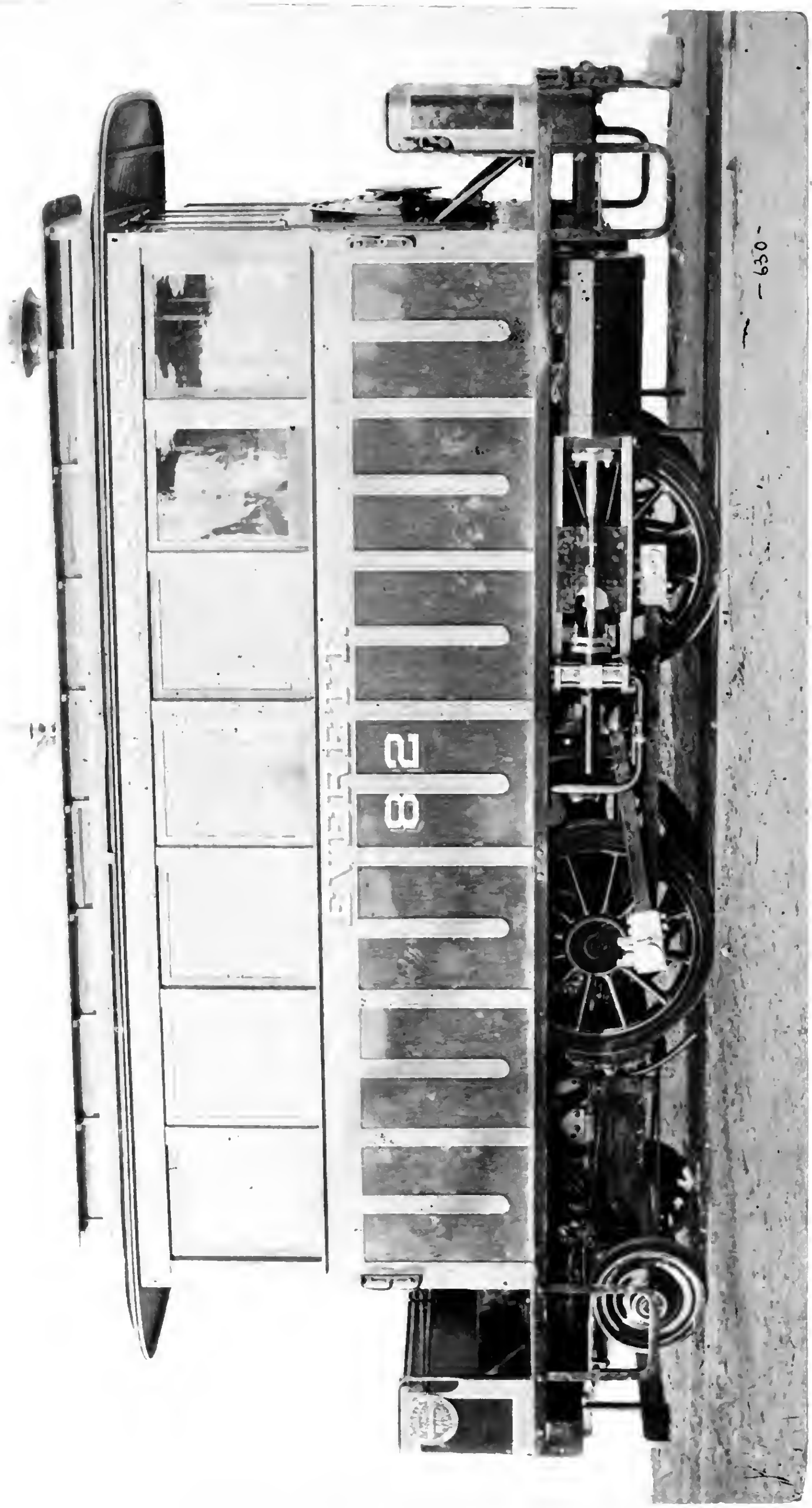


8⅓ D Tank.

The classes of locomotives described in preceding table (page 147) can be constructed with a swinging truck added, of either two or four wheels. A tank for water can be placed on boiler and a fuel-box provided over the truck, as in type **8⅓ D tank**; or a tank for water, with space for fuel, can be provided over the truck, as in type **10⅓ D**; or, besides the tank and fuel space over truck, an additional tank can be placed on boiler, as in type **10⅓ D, with additional tank on boiler.**

The dimensions of cylinders and driving-wheels, the wheel-base of driving-wheels, and the tractive power would be the same as for the classes with corresponding cylinders in the table on page 147.

Locomotives of these types would be suitable for heavy switching and local freight service. They would also be especially adapted to working steep grades, and, by running with the truck ahead, passing short curves.



INCLOSED NOISELESS LOCOMOTIVES,

FOR SWITCHING OR PASSENGER SERVICE IN CITY STREETS.

The classes of locomotives described in the tables on pages 118, 125, 128, 136, and 144 can be built with a house entirely covering and concealing the boiler and most of the machinery, as shown in photograph on page 150.

A patent exhaust chamber is provided, into which the exhaust steam passes, muffling the noise of the exhaust sufficiently to render it unobjectionable. The steam from the cylinder cocks can also be diverted into the same chamber, if desired.

By the use of anthracite coal or coke as fuel no smoke will be shown. Provision can also be made, if required, for preventing the showing of most of the exhaust steam.

By these means locomotives can be provided available for service in the streets and suburbs of cities.

Locomotives of this description have been constructed for the following companies: The Long Island Railroad Company, The Memphis and Charleston Railway Company, The Richmond, Fredericksburg and Potomac Railway Company, The Boston, Lowell and Nashua Railway Company, and the Boston and Maine Railroad Company.

Following, we give letters from officers of several of the companies named, with reference to the workings of the respective engines on their lines.

MEMPHIS AND CHARLESTON RAILROAD.
MEMPHIS, TENN., October 11, 1876.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.:

Gents,—The Dummy engine ("Mayor Flippin") built by you for this company arrived safe and was put up by your engineer. She works first-rate in every respect, and I am sure she will do work that she is intended for.

Your engineer hauled with the engine ten cars up the Washington Street grade with ease.

The patent exhaust is a success without a doubt, and I think is the best thing out for an engine that has to run in cities and towns.

The engine came here with wood-burning grates in her, and I had to take them out and put our coal-burning grates into her.

With best wishes, I am yours, etc.,
(*Signed*) H. N. BURFORD,
Master Mechanic.

MEMPHIS AND CHARLESTON RAILROAD.
MEMPHIS, TENN., June 18, 1878.

MESSRS. BURNHAM, PARRY, WILLIAMS & CO.,
BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA, PA.:

Gentlemen,—In addition to what I have heretofore said about the dummy locomotive "Mayor Flippin," I can further state that the engine has given entire satisfaction up to date and does its work well.

The patent exhaust is a success without a doubt. As the engine passes by horses in the streets they do not notice it any more than they do a wagon. Our track runs through one of the most active business streets in the city.

The "Mayor Flippin" makes from three to five trips per day; has not lost a single trip, and has not cost us a cent for repairs.

(*Signed*) H. N. BURFORD,
Master Mechanic.